TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1899

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BY

SIR JAMES HECTOR, K.C.M.G., M.D., F.R.S.

Director

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NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867."

BOARD OF GOVERNORS.

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SECRETARY: R. B. Gore.

ABSTRACTS OF RULES AND STATUTES.

GAZETTED IN THE "NEW ZEALAND GAZETTE," 9TH MARCH, 1868.

SECTION I.

Incorporation of Societies.

1. No society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1867," unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than fifty pounds sterling annually for the promotion of art, science, or such other branch of knowledge for

which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the Chairman for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £50.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the Museum and library of the New Zealand Institute.

4. Any society incorporated as aforesaid, which shall in any one year fail to expend the proportion of revenue affixed in manner provided by Rule 3 aforesaid, shall from thenceforth cease to be incorporated with the Institute.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and may then be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

Regulations regarding Publications.

(*a*.) The publications of the Institute shall consist of a current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute," and of transactions, comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), to be intituled "Transactions of the New Zealand Institute."

(*b*.) The Institute shall have power to reject any papers read before any of the incorporated societies.

(*c*.) Papers so rejected will be returned to the society in which they were read.

(*d*.) A proportional contribution may be required from each society towards the cost of publishing the Proceedings and Transactions of the Institute.

(*e*.) Each incorporated society will be entitled to receive a *proportional* number of copies of the Proceedings and Transactions of the Institute, to be from time to time fixed by the Board of Governors.

(*f*.) Extra copies will be issued to any of the members of incorporated societies at the cost-price of publication.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. Subject to "The New Zealand Institute Act, 1867," and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the Chairman and countersigned by the Secretary of any society, accompanied by the certificate required under Rule No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing rules of the Institute are complied with by the society.

SECTION II.

For the Management of the Property of the Institute.

9. All donations by societies, public departments, or private individuals to the Museum of the Institute shall be acknowledged by a printed form of receipt, and shall be duly entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

10. Deposits of articles for the Museum may be accepted by the Institute, subject to a fortnight's notice of removal, to be given either by the owner of the articles or by the Manager of the Institute, and such deposits shall be duly entered in a separate catalogue.

11. Books relating to natural science may be deposited in the library of the Institute, subject to the following conditions:—

(*a*.) Such books are not to be withdrawn by the owner under six months' notice, if such notice shall be required by the Board of Governors.

(*b*.) Any funds especially expended on binding and preserving such deposited books at the request of the depositor shall be charged against the books, and must be refunded to the Institute before their withdrawal, always subject to special arrangements made with the Board of Governors at the time of deposit.

(*c*.) No books deposited in the library of the Institute shall be removed for temporary use except on the written authority o receipt of the owner, and then only for a period not exceeding seven days at any one time.

12. All books in the library of the Institute shall be duly entered in a catalogue, which shall be accessible to the public.

13. The public shall be admitted to the use of the Museum and library, subject to by-laws to be framed by the Board.

SECTION III.

The laboratory shall for the time being be and remain under the exclusive management of the Manager of the Institute.

SECTION IV.

(OF DATE 23RD SEPTEMBER, 1870.)

Honorary Members.

Whereas the rules of the societies incorporated under the New Zealand Institute Act provide for the election of honorary members of such societies, but inasmuch as such honorary members would not thereby become members of the New Zealand Institute, and whereas it is expedient to make provision for the election of honorary members of the New Zealand Institute, it is hereby declared,—

1. Each incorporated society may, in the month of November next, nominate for election, as honorary members of the New Zealand Institute, three persons, and in the month of November in each succeeding year one person, not residing in the colony.
2. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the Manager of the New Zealand Institute, and shall by him be submitted to the Governors at the next-succeeding meeting.
3. From the persons so nominated the Governors may select in the first year not more than nine, and in each succeeding year not more than three, who shall from thenceforth be honorary members of the New Zealand Institute, provided that the total number of honorary members shall not exceed thirty.

ROLL OF INCORPORATED SOCIETIES.

NAME OF SOCIETY.	DATE OF INCORPORATION.
Wellington Philosophical Society	10th June, 1868.
Auckland Institute	10th June, 1868.
Philosophical Institute of Canterbury	22nd Oct., 1868.
Otago Institute	18th Oct., 1869.
Westland Institute	21st Dec., 1874.
Hawke's Bay Philosophical Institute	31st Mar., 1875.
Southland Institute	21st July, 1880.
Nelson Philosophical Society	20th Dec., 1883.

OFFICERS OF INCORPORATED SOCIETIES, AND EXTRACTS FROM THE RULES.

WELLINGTON PHILOSOPHICAL SOCIETY.

Office-bearers for 1900.—*President*—G. V. Hudson, F.E.S.; *Vice-presidents*—Sir J. Hector, K.C.M.G., M.D., F.R.S., H. B. Kirk, M.A.; *Council*—George Denton, Martin Chapman, George Hogben, M.A.; R. C. Harding, H. N. McLeod, R. L. Mestayer, M.Inst.C.E., E. Tregear, F.R.G.S.; *Secretary and Treasurer*—R. B. Gore; *Auditor*—T. King.

Extracts from the Rules of the Wellington Philosophical Society.

5. Every member shall contribute annually to the funds of the Society the sum of one guinea.

6. The annual contribution shall be due on the first day of January in each year.

7. The sum of ten pounds may be paid at any time as a composition for life of the ordinary annual payment.

14. The time and place of the general meetings of members of the Society shall be fixed by the Council, and duly announced by the Secretary.

AUCKLAND INSTITUTE.

Office-bearers for 1900.—*President*—Professor H. W. Segar; *Vice-presidents*—J. Batger, Professor H. A. Talbot-Tubbs; *Council*—Professor F. D. Brown, C. Cooper, F. G. Ewington, E. A. Mackechnie, P. Marshall, F.G.S., T. Peacock, D. Petrie, F.L.S., J. A. Pond, F.C.S., J. Stewart, C.E., Professor A. P. Thomas, F.L.S., J. H. Upton; *Trustees*—E. A. Mackechnie, T. Peacock, J. H. Upton; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.; *Auditor*—W. Gorrie.

Extracts from the Rules of the Auckland Institute.

1. Any person desiring to become a member of the Institute shall be proposed in writing by two members, and shall be balloted for at the next meeting of the Council.

4. New members on election to pay one guinea entrance-fee, in addition to the annual subscription of one guinea, the annual subscription being payable in advance on the first day of April for the then current year.

5. Members may at any time become life-members by one payment of ten pounds ten shillings in lieu of future annual subscriptions.

10. Annual general meeting of the society on the third Monday of February in each year. Ordinary business meetings are called by the Council from time to time.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

OFFICE-BEARERS FOR 1900.—*President* — Captain F. W. Hutton; *Vice-presidents*—L. Cockayne, J. B. Mayne; *Hon. Secretary* — Professor A. Dendy; *Hon. Treasurer* — Captain F. W. Hutton; *Council* — Dr. Symes, H. R. Webb, R. M. Laing, Professor Wall, Professor Scott, J. S. S. Cooper; *Hon. Auditor*—George Way.

Extracts from the Rules of the Philosophical Institute of Canterbury.

8. Every member of the Institute other than honorary shall pay one guinea annually as a subscription to the funds of the Institute. The subscription shall be due on the 1st January in each year.

9. Members may compound for all annual subscriptions of the current and future years by paying ten guineas.

15. The ordinary meetings of the Institute shall be held monthly during the months from May to November, both inclusive, on such day as the Council may determine.

OTAGO INSTITUTE.

OFFICE-BEARERS FOR 1900.—*President*—E. Melland; *Vice-presidents*—F. R. Chapman, Alex. Bathgate; *Council*—Dr. Hocken, Dr. Barnett, G. M. Thomson, A. Hamilton, F. Barningham, C. W. Chamberlain, F. B. Stephens; *Hon. Secretary*—Professor W. B. Benham; *Hon. Treasurer*—J. Crosbie Smith; *Auditor*—D. Brent.

Extracts from the Constitution and Rules of the Otago Institute.

2. Any person desiring to join the society may be elected by ballot, on being proposed in writing at any meeting of the Council or society by two members, and on the payment of the annual subscription of one guinea for the year then current.

5. Members may at any time become life-members by one payment of ten pounds and ten shillings in lieu of future annual subscriptions.

8. An annual general meeting of the members of the society shall be held in January in each year, at which meeting not less than ten mem-

bers must be present, otherwise the meeting shall be adjourned by the members present from time to time until the requisite number of members is present.

(5.) The session of the Otago Institute shall be during the winter months, from May to October, both inclusive.

WESTLAND INSTITUTE.

Office-bearers for 1900.—*President*—Mr. A. J. Morton; *Vice-president*—Mr. A. Mahan; *Hon. Treasurer*—Mr. G. K. Sinclair; *Trustees*—Messrs. Clarke, Dawes, Perry, Macfarlane, McNaughton, Michel, Beare, Solomon, Park, Lewis, Drs. Macandrew and Teichelmann.

Extracts from the Rules of the Westland Institute.

3. The Institute shall consist (1) of life-members—*i.e.*, persons who have at any one time made a donation to the Institute of ten pounds ten shillings or upwards, or persons who, in reward of special services rendered to the Institute, have been unanimously elected as such by the committee or at the general half-yearly meeting; (2) of members who pay two pounds two shillings each year; (3) of members paying smaller sums, not less than ten shillings.

5. The Institute shall hold a half-yearly meeting on the third Monday in the months of December and June.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

Office-bearers for 1900.—*President*—W. Dinwiddie; *Vice-president*—T. Hall; *Council*—J. E. H. Jarvis, M.R.C.S., J. Caughley, H. Hill, B.A., F.G.S., F. A. Tregelles, T. Tanner, T. C. Moore, M.D.; *Hon. Secretary*—James Hislop; *Hon. Treasurer*—J. W. Craig; *Hon. Auditor*—G. White.

Extracts from the Rules of the Hawke's Bay Philosophical Institute.

3. The annual subscription for each member shall be one guinea, payable in advance on the first day of January in every year.

4. Members may at any time become life-members by one payment of ten pounds ten shillings in lieu of future annual subscriptions.

(4.) The session of the Hawke's Bay Philosophical Institute shall be during the winter months from May to October, both inclusive; and general meetings shall be held on the second Monday in each of those six months, at 8 p.m.

SOUTHLAND INSTITUTE.

Office-bearers.—*Trustees*—Ven. Archdeacon Stocker, Rev. John Ferguson, Dr. James Galbraith.

NELSON PHILOSOPHICAL SOCIETY.

Office-bearers for 1900.—*President*—The Bishop of Nelson; *Vice-presidents*—A. S. Atkinson and Dr. Mackie; *Council*—The President, the Vice-presidents, the Secretary, the Treasurer, and F. G. Gibbs, E. Lukins, Dr. Boor, Rev. F. Chatterton, and J. G. Bartel; *Hon. Secretary*—R. I. Kingsley; *Hon. Treasurer*—Dr. Hudson; *Hon. Curator*—R. I. Kingsley; *Hon. Assistant Curator*—E. Lukins.

Extracts from the Rules of the Nelson Philosophical Society.

4. Members shall be elected by ballot.

6. The annual subscription shall be one guinea.

7. The sum of ten guineas may be paid in composition of the annual subscription.

16. Meetings shall be held on the second Monday in every month.

23. The papers read before the Society shall be immediately delivered to the Secretary.

TRANSACTIONS

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OF THE

NEW ZEALAND INSTITUTE,

1899.

I.—ZOOLOGY.

Art. I.—*Zoological Results of Trawling Trials off the Coast of Otago.*

By Professor Benham, D.Sc., M.A., F.Z.S.

[Read before the Otago Institute, 11th July, 1899.]

Early in the year the Otago Harbour Board lent their tug, the s.s. "Plucky," for the use of a party of gentlemen, some interested in commercially valuable products of the sea, others in scientifically interesting inhabitants. The opportunity of seeing an otter-trawl at work in comparatively deep water, and of collecting zoological material brought up by it, was thus afforded to and seized upon by me. There were two expeditions made—one in the day-time, on the 27th February, when the boat went northwards for a distance of about three miles, and trawled in about 10 to 20 fathoms; the second was a nocturnal trip—4th to 5th March—when the boat went much further eastwards and southwards, trawling in water varying from 10 to 30 fathoms.

It appears to be of interest to put on record the more important animals collected by us, since new localities for known species are established, and a number of species that appear to be new were obtained.

It must be mentioned that we had no small "dredge" for collecting. It is true I took a surface-net with me, but I am not concerned at present with the plankton. The following

animals were brought up in the wide-meshed otter-trawl, and represent only a tithe or a hundredth part of the material awaiting capture immediately outside the harbour; and in the near future I hope to have the opportunity of going over the sandy banks here with a small-meshed dredge.

The following is a list of the more interesting forms. It is to be borne in mind that shells are mentioned only when they contained the living animal:—

MOLLUSCA.

Voluta pacifica: Three specimens.
Zizyphinus cunninghami: Quantities.
Struthiolaria papulosa: Three.
Astralium imperator: Four.
Pecten zealandica: Several.
Doris (a large violet species): Seven.

CRUSTACEA.

Acanthopteryx.
Leptomithrax.
Hermit crabs: Several.
Pontophilus australis.
Cassidina neo-zealanica.
Lilljeborgia haswelli.
Balanus porcatus.

ECHINODERMA.

Astrogonium abnormale: Several.
Gnathaster, sp.: One.
Asterias, sp. (fine, scarlet).
Asterina regularis: In abundance.
Holothurian: A fine species, about 10 in. or 12 in. long.

ANNELIDA.

Branchellion, on *Raia*, sp.
Pontobdella.
Phyllodocids.
Nereids.
Polynoids, &c.

Also a number of sea-anemones, of which one was especially handsome — a large bright-red column, with white tubercles in rows; also a number of smaller anemones, hydroids, and sponges, as well as compound Ascidians, which I have not as yet attempted to identify.

This is not a very great collection, nor widely representative, but it presents instances of bionomics that are of some interest.

An interesting instance of commensalism came into view in smashing the shells inhabited by the hermit crab—chiefly *Struthiolaria* and *Fusus* shells. In the upper part of the shell, above or at the side of the Pagurid's abdomen, was found, in several instances, an Annelid, closely allied to the common *Nereis* that occurs in mud or sand below stones along the coast. This worm, however, is stouter and more brightly coloured than the shell-worm. It is banded alternately reddish-brown and white, and is remarkable in that the first pectoral segment is produced forwards round the head as a free collar-like flap. It is an entirely new species, and may possibly be the type of a new genus—new not only to New Zealand, but to science. As I have not yet fully examined it I withhold its name, since I cannot here give a detailed description of it. I found both males and females. In the latter the green eggs within partially killed the brown colour of the body-wall. The males and females occurred isolated: I did not find more than one worm in each shell.

Each hermit crab was accompanied by a second messmate in the shape of a small shrimp-like animal, which Mr. G. M. Thomson has been good enough to name for me: it is *Lillje-borgia haswelli.* This little amphipod is peculiarly coloured—the head end is red, the tail half is white. It occupied the topmost whorl of the shell; and I do not remember seeing more than one at a time.

Hermit crabs have long been known to be accompanied by a Nereid, but I believe the occurrence of an amphipod together with the other two is a novelty.

The crabs afforded excellent examples of "protection," for the carapace was entirely concealed by foreign growth—sponges, hydroids, &c.—and even the exposed parts of some of the appendages bore their share.

A brief reference to a beautiful *Doris* may be added. We obtained six or seven large violet Dorids, measuring from 4 in. to 7 in. long during life, and about 3 in. broad and about 1½ in. high. The most remarkable feature, apart from the size and colour, lies in the closely set, rounded, flattened papillæ, of various sizes, large and small, into which the skin of the entire dorsal and lateral surfaces is raised up, some of the papillæ measuring nearly ½ in. across. This is not unlike Abraham's *D. wellingtonensis*, but there is nothing in his description that enables me to identify this find with his much smaller Dorid.

Art. II.—*Note on* Cordyceps sinclairii, *Berkeley.*

By Professor W. B. Benham, D.Sc., M.A., F.Z.S.

[*Read before the Otago Institute, 12th September, 1899.*]

Plate I.

The group of colourless plants referred to by the botanist as "fungi" include a number of organisms having very varied habitats and interesting life-histories. For example, the edible mushroom; the numerous toadstools, many of large size and conspicuous colouration; the minute "blue moulds" growing on jam, old boots, stale moist bread, and in various other situations; a number of still less noticeable species occurring as saprophytes or parasites in plants, and producing gall-like malformations and other diseases, such as "rusts," mildews, and so forth; and, finally, there are several genera that attack living animals, causing disease and bringing about their destruction.

Amongst these so-called parasitic fungi there is one genus, *Cordyceps*, that is confined to insects. A good number of species are known, each attacking a different insect. The general mode of attack is, as far as is known, as follows: During the resting-period of the insect, when the larva is preparing to enter the stage preceding its metamorphosis into the imago stage, or complete insect, spores of the fungus gain entrance into its tissues. Here the spores give rise to thread-like "hyphæ," which make their way in all directions through the living tissues of the insect's body, absorbing nourishment therefrom. As a consequence the fungus grows, and gradually replaces entirely the tissues of the animal, which has slowly died. Up to this period the plant has been invisible from the outside, but now it proceeds to "fructify." For this purpose some of the hyphæ push their way, as a compact bundle, through the skin of the insect, and grow upwards into the air. The purpose of this exposure is to insure scattering of the spores destined to be formed by these "aerial hyphæ." This dissemination is effected by the wind or other external agent. They thus have an opportunity of reaching another insect, or living organism, so that the life-history may be continued.

The vegetable caterpillar, which is fairly well known to New Zealand naturalists, and has been referred to by a number of observers in the pages of the Transactions, is a fungus called *Cordyceps robertsii*, Hooker, 1843 (or, as it is more correctly named according to the laws of priority, *C. hugelii*,

Corda, 1842). A large number of other species are known in other lands, and these have been recently described and figured by Mr. G. Massee in the "Annals of Botany" (vol. ix., 1895), wherein will be found an epitome of all that is known about the matter.

In New Zealand we have a second species attacking the larva of the singing-locust (*Cicada*). This species, known as *Cordyceps sinclairii*, was originally named by Berkeley in his "Flora of New Zealand" (1855): it is figured by him in his "Introduction to Cryptogamic Botany" (p. 73, fig. 17), and also by Taylor in his "New Zealand and its Inhabitants" (p. 647). Both these figures are rather crude; but, except for cursory references to it by Mr. Maskell and Mr. A. Hamilton in their papers on the vegetable caterpillar in the Transactions, I can find no further account of this species.

Massee, in his monograph above referred to, merely quotes Berkeley's description, who gave as its habitat, "Northern Island (New Zealand); in the larva of some orthopterous insect; amongst loose gravelly soil." Hooker records it from a coleopterous larva.

Last month (August) I received two well-preserved specimens of this vegetable *Cicada* from the lightkeeper at Farewell Spit, who had been good enough to comply with a request of mine to preserve, in a bottle of formol that I had forwarded to him, any animals of interest that he met with. My thanks are due to him for these specimens, as well as for some very fine large *Scalpellum*, which appear to be new to science.

The two specimens of *C. sinclairii* are at different stages of development, and are so different in appearance from *C. hugelii* (= *robertsii*) that I looked into the literature of the subject, and, as a result, proceeded to investigate the matter.

The fungus, in this stage, makes its way out of the insect near the anterior end, as in all normal cases of *Cordyceps* hitherto recorded. It issues between the head and pronotum. The main branch grows straight forward for some distance and gives off branches right and left in a very characteristic fashion. At first the fungus is cylindrical, white in colour, with a certain amount of pink in places.* In one specimen the branches are few and short (figs. 1, 2); in the other (fig. 3) they are more numerous, and the whole aspect is much more elaborate, and resembles a deer's antlers. The branches lose their cylindrical shape and become irregular; some others broaden out, become more or less flattened, and are very

* Berkeley states that *C. sinclairii* is yellowish. It must be borne in mind that the above description refers to specimens preserved in formol, but the colour of the dried fungus is practically the same, though the pink tint is less pronounced. Possibly "yellowish"-brown might apply to a dried specimen.

irregularly arranged. The pink colour is now more extensively developed and shades into a brown, the white being limited to the axils of the branches. These changes are connected with the maturity of the fungus. In addition to the main post-cephalic bundle of hyphæ, other smaller ones, in the older specimens, issue from the joints of the legs and from the sides of some of the segments.

A still further stage in maturity was represented by a dried specimen given to me by Mr. Hamilton. Here several long main stems issue behind the head, and one behind the pronotum, and run side by side directly forward. These are less branched than in my specimen.

A comparison of the mature condition of *C. sinclairii* with that of *C. hugelii* shows very remarkable and easily recognisable differences (quite apart from the absence of branching in the latter), illustrating two distinct methods of spore-formation.

If an aerial fructifying branch of *C. hugelii* be examined even with the naked eye, it is seen to terminate in a long, velvety, thickened region, sharply marked off from the more woody base or stalk. This upper region owes its velvety appearance to a vast number of closely set yellowish vesicles (or perithecia), each of which, on further examination, may be found to contain eight long filamentous spores packed side by side. But the closest and most careful superficial examination of *C. sinclairii* shows nothing of the kind; there are no perithecia, the surface of the brown-pink region is quite smooth. If, however, this fungus be submitted to microscopical examination, either by the simple method of teasing up with needles, or, better, by cutting sections across it with a razor, it will be found that below this smooth surface, formed of closely arranged fungal hyphæ, innumerable spores occur, but of quite a different size and shape and arrangement. These spores are short and oval, quite irregularly arranged amongst the hyphæ. Further, they are produced in a manner quite different from that exhibited by *C. hugelii*. In fact, these two species of New Zealand *Cordyceps* illustrate the two chief modes of reproduction by spore-formation recognised by botanists as occurring in the group of fungi, and which generally occur in two different stages in the life-history of one and the same species of fungus.

The two different modes of spore-formation yield different kinds of spores—(1) *Ascospores*, formed by subdivision of the protoplasm inside a single cell or "ascus"; (2) *Conidiospores*, formed by constriction of a hypha, so as to form a row of spores arranged more or less like a string of pearls or beads.

Without entering into further details, it must suffice to state that the fructification of most of the species of *Cordyceps* with which we are acquainted is known only in the

ascospore stage (as in the vegetable caterpillar of New Zealand, *C. hugelii*), while nothing is known of the other stage—the conidiospore stage—of the life-history; but in a few European species, such as *C. militaris* and *C. entomorhiza*, both stages in the life-history of the fungus are known, and the relation of one to the other has been worked out. From experimental researches on these species we know that the conidial stage is a saprophytic form, which may grow on leaves, bark, wood, &c., and not necessarily on insects, and has been hitherto regarded as a distinct genus of fungus, to which the name *Isaria* had been given, while the ascospore stage is, of course, that condition known as infesting the insect. Thus *C. militaris* is the ascospore stage of a fungus of which the conidial stage has been known as *Isaria farinosa;* and *C. entomorhiza*,* infesting the larvæ of various insects, has as its conidial stage *I. densa*, which normally occurs on the larva of the cockchafer (*Melolontha*). These two stages do not occur at the same period of the year, but it appears that a resting-stage, known technically as "sclerotium," intervenes.

From these and other facts botanists consider it likely that each of the species of *Cordyceps* has its own "isarial" stage, though this can only be ascertained by experiments similar to those that have enabled the facts above mentioned to be determined.

Now, the chief interest in my own observations on *C. sinclairii* lies in the fact that it is the conidial stage of a fungus—a fact already noted, I may state, by Berkeley. We do not know its ascospore stage, and one is inclined to suggest that possibly the two fungi known as *C. sinclairii* and *C. hugelii* may be merely links in the chain of events in the life-history of one species of *Cordyceps*. But this can only be determined by direct experiments with living organisms—by sowing the spores of *C. sinclairii* (from the *Cicada*) in the tissues of the caterpillar, and ascertaining whether they give rise to *C. hugelii*. It is manifestly a difficult experiment to perform, and a considerable number of living fungi and insects would be required; and since we do not know with certainty what species of caterpillar (and whether more than one) is attacked by *C. hugelii*, it will be necessary to make a further investigation into the whole subject.†

* Massee records *C. entomorhiza* as occurring in New Zealand as well as in Europe. He does not state its host in New Zealand; the only detail given is "(Coll. Colenso)."

† In looking at Taylor's book I note that on page 641 he refers to "*Mumutawa*, the largest beetle of New Zealand," living on sandhills, as being infested by a "fungus, which entirely occupies its body, without sending up any shoot." It is desirable to look into this matter, and I should be very grateful for specimens—preferably fresh; otherwise, preserved in alcohol or formol.

Postscript (December).—I have throughout spoken of this parasite of *Cicada* larva as *C. sinclairii*, though I am by no means certain that this identification is correct. Berkeley states that his specimen is "yellowish," inclining to "lemon-coloured" at the edges. Now, neither the dried specimens nor carefully preserved ones are yellow: if the terms "brownish" or "pinkish" be used, either is true. Moreover, while Berkeley's figure is very similar to Mr. Hamilton's specimen, it differs from my own specimens from Farewell Point. However, the latter difference is not one that has any importance; and, with regard to the colour, it may be that when fully mature, when all the spores that can be formed are formed, the fungus turns yellow. For the present it is less confusing to retain Berkeley's name for the fungal destroyer of our *Cicada* larva, especially as only one other case of a similar insect being attacked by *Cordyceps* is known—viz., *C. cicadæ*, Miquel, from Brazil—and it is improbable that there is any connection between the two species. I have been unable to find an account of the Brazilian species, which appears to be very imperfectly described.

EXPLANATION OF PLATE I.

[The figures are mere outlines, tracings from more elaborate sketches carefully drawn to scale. The magnification of the figures is about twice the natural size.]

Fig. 1. Side view of *Cicada* larva, with a young fructification of *Cordyceps sinclairii* issuing from its neck, and a small one from the base of the right fore leg (the other legs are represented as being cut short). The greater part of the main aerial bundle is white, but the tips are pink.

Fig. 2. Dorsal view of fore part of same larva, showing the three main branches of the aerial bundle and a small vertical branch.

Fig. 3. A *Cicada* larva with a very well developed *Cordyceps*. The single main axis branches almost at once into a number of more or less bifurcated lobes, flattened, and brown-pink in colour; the bases only are now white, though here and there white patches persist.

Bundles of white hyphæ of the fungus are seen issuing from all the thinner parts of the body-wall, between the abdominal and thoracic segments, and from various parts of the fore leg and second leg (which is bent up against the body); the third leg is removed.

ART. III.—*Note on the Occurrence of the Genus* Balanoglossus *in New Zealand Waters.*

By Professor BENHAM, D.Sc., M.A., F.Z.S.

[*Read before the Otago Institute, 12th September, 1899.*]

ALTHOUGH an account of this new species of *Balanoglossus* has already been published in England,* it appears to be of sufficient interest to record its occurrence in a journal of wider distribution in New Zealand, since it is the first-recorded representative in our waters of a class of animals of considerable zoological interest. The genus *Balanoglossus,* together with a few other similar worm-like animals, constitutes a group of animals which is closely associated with the ancestors of the great vertebrate class, and nearly allied to the sea-squirts, or Ascidians, and to the Lancelets.

This group of worm-like creatures is known to zoologists as *Enteropneusta*, or *Hemichorda*, and of this group only one species has hitherto been recorded from Australasian waters. A few years back (1893) a species—*Ptychodera australiensis*—was discovered by Mr. Hill, and the anatomy fully described.† But the type genus, *Balanoglossus*, had not been recorded from any part of the Southern Hemisphere till the discovery by Mr. Hamilton of the subject of the present note.

We were pottering about the Otago Harbour, at Port Chalmers, in February, 1899, doing a little collecting, when Mr. Hamilton observed a small red worm creeping along a piece of kelp. He passed it over to me for examination, and on placing it in a bottle of water I was surprised and delighted to find that it was an Enteropneustic worm. Shortly afterwards we obtained a second and smaller worm, of a more orange colour. On returning to my laboratory I lost no time in submitting the worm to careful examination, with the result that I discovered it to be a new species of the genus *Balanoglossus*, to which I have given the name *B. otagoensis*.

It may not be amiss to give a brief account of the external features of the worm, and to ask any member who is interested in natural history to keep a look out for it, and on finding it to place it, as soon as possible, in alcohol or other suitable preservative, and to forward it to me.

The specimen was a mature female, coloured rich carmine-red, the anterior end having the deepest tint. The entire length of the animal when extended crawling is but $1\frac{1}{8}$ in.—quite a

* "Quarterly Journal of Microscopical Science," xlii., 1899.
† T. P. Hill, Proc. Linn. Soc. N.S.W., 1895.

small worm then, easily overlooked. The animal is soft-bodied, subcylindrical, without legs or feelers or appendages of any sort, without shell or other hard parts; but it is easily distinguished from ordinary marine worms in that the body presents the three following well-marked regions: (1) The anterior end of the body is an elongated cone, bluntly pointed at the tip, and fairly mobile (it is remarkable in this species for possessing a groove running along its dorsal surface); this "proboscis" is in life not quite ¼ in. long. Its base is surrounded by (2) a collar-like region of very short extent; and beyond this is (3) the body proper, tapering off posteriorly, but not ending in any definite tail.

It is unnecessary for me to enter into any anatomical details—these will be found elsewhere; but I give an outline drawing of the worm to aid the above description.

Outline Sketch of Balanoglossus otagoensis (× 4).

1. Proboscis, with dorsal groove.
2. Collar.
3. Body.

Art. IV.—*Notes on* Macro-lepidoptera *observed during the Summer of 1898–99.*

By G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 19th September, 1899.*]

The following notes refer to a few observations on *Macro-lepidoptera*, which have been made since the publication of my book on "New Zealand Moths and Butterflies."

Dasypodia selenophora.

This large and handsome insect was unusually common during the past summer. Several specimens were obtained in the Hutt Valley by Sir James Hector, and by Mr. Williams. A specimen was also found at Karori, where, so far as I am aware, the insect had never occurred previously, although I have worked the locality continuously since 1882. Last April I received a very fine specimen from Wanganui, and about

the same time Mr. A. P. Buller informed me that he had taken a magnificent specimen near Featherston.

Paradetis porphyrias.

During a visit to Wainuiomata early last December I found this species quite commonly flying amongst the ferns which fringe the road on the northern side of the reservoir. Previously, the insect was only recorded from a few mountain localities in the South Island, so that its occurrence at Wainuiomata is very interesting. I, however, expected that the moth would prove to be more generally distributed than was at first supposed. ("New Zealand Moths and Butterflies," p. 41.)

Asaphodes siris.

Two specimens of this species have been taken near Wellington by Mr. Hawthorne since the publication of his description of the insect in vol. xxix. of the Transactions. The three specimens which are thus available exhibit no variations, and prove beyond all doubt the distinctness of the species.

Selidosema fenerata.

Early last February I succeeded for the first time in working out the life-history of this species. The larva, which was discovered feeding on *macrocarpa*, is very handsome. Its length when full grown is about 1 inch. The general colour is vivid green, with shining white markings. There is a broad lateral line, with an interrupted line above it; a series of large crescentic marks down the back, with a white dash in the middle of each; two interrupted subventral white lines. The head is green, with a rusty-brown mark on each side. This larva is very inconspicuous amongst the foliage of the *Macrocarpa*, and its colouring is evidently protective. Originally its food-plant was probably rimu, amongst the foliage of which the caterpillar's remarkable colouring would probably be equally efficient for protective purposes. The pupa is concealed about 1 inch below the surface of the earth. The perfect insects emerged towards the end of March; but in a state of nature *S. fenerata* is found during most of the year.

Azelina fortinata.

In December last this species was extremely abundant at Wainuiomata, frequenting clumps of *Lomaria* (?), a fern which occurred plentifully in many parts of the forest above the reservoir. I have always noticed this insect attached to this particular fern, and I expect that its larva feeds thereon; but, although I spent some hours in searching, I was unable to find any specimens of the larva. Many of the fronds were

eaten, and very probably a careful examination of the ferns during the latter end of October or beginning of November would result in the discovery of the larva. The perfect insect was about at the time of my visit, therefore it was possibly a month or six weeks too late in the season for the larva to be found.

Declana floccosa.

In October, 1897, I captured in my garden at Karori a specimen of this insect, with the central band of the forewings unusually broad and extremely dark in colour. It is quite a new variety to me, and differs considerably from any of the numerous varieties of *D. floccosa* which I have previously described and figured. (See "New Zealand Moths and Butterflies," p. 96.)

Sphinx convolvuli.

On the 15th January last Sir James Hector kindly sent me some larvæ of this handsome insect. It is an extremely difficult caterpillar to rear, and I have only succeeded in bringing one specimen to the pupa state, and it is doubtful whether even this specimen will ever give rise to a moth. The larvæ appear to have been plentiful in the neighbourhood of Picton during last summer. As a rule *S. convolvuli* is not found southward of Napier and New Plymouth, although it is occasionally common in the more northern districts.

Vanessa itea.

This insect was extremely abundant during the past autumn. At Easter the weather was exceptionally fine and mild, and I observed many specimens of this beautiful butterfly in my garden at Karori. It was then certainly quite as common as *Vanessa gonerilla*. During the same holidays a very fine series of over a dozen specimens of *V. itea* was taken by Miss Blair on the flowers of a heliotrope in her garden in Grant Road, which series I have much pleasure in exhibiting before the Society this evening. Mr. Powles has also observed this butterfly in large numbers in his garden, and I think that the past season will be remembered as the "*itea*" year, by every one in Wellington who is interested in butterflies.

Porina characterifera.

Of this rare and beautiful species I captured one very fine specimen at Kaitoke on the 9th November last. It was resting with closed wings on the moss-covered trunk of a birch-tree, where it was extremely difficult to see. Although I spent fully two hours examining other tree-trunks in the vicinity, I did not succeed in finding any others.

ART. V.—*Note on the Fresh-water Crayfishes of New Zealand.*

By CHARLES CHILTON, M.A., D.Sc., M.B., C.M., F.L.S., Research Fellow, University of Edinburgh.

[*Read before the Philosophical Institute of Canterbury, 6th October, 1899.*]

SOME years ago I published a paper on "The Distribution and Varieties of the Fresh-water Crayfish of New Zealand."* My collection was deposited in the Dunedin Museum, and shortly afterwards the whole collection, together with some additional specimens afterwards collected, was, with the kind consent of the late Professor T. J. Parker, forwarded to Professor Walter Faxon, of Cambridge, U.S.A., for use in the preparation of the second part of his "Revision of the *Astacidæ*," which was to treat of the South Hemisphere genera of fresh-water crayfish. Unfortunately, the material at his command did not include sufficient specimens from Australia, Tasmania, and South America to enable him to complete a satisfactory revision of the *Parastacinæ* as a whole, but such results as he could obtain he has recently published in the "Proceedings of the United States National Museum,"† and in this paper he deals pretty fully with the New Zealand crayfishes. As his work may not be accessible to many in New Zealand, I have thought it well to give a short account of his results here, especially as on one point they differ somewhat from my own.

Faxon divides the crayfishes of New Zealand into three species, viz.: (1) *Paranephrops planifrons*, White; (2) *Paranephrops zealandicus*, White; (3) *Paranephrops setosus*, Hutton.

I had considered the last two species as merely varieties of a single species, which I described in my paper under the name *P. neo-zelanicus*, and I there mentioned most of the points of difference which Faxon relies upon for the separation of the two species, and so long as these are recorded and recognised it matters little whether we divide the specimens into two species or two varieties of one species. Professor Faxon has, however, had such great experience in dealing with species of crayfishes that it will probably be wise to follow him in recognising *P. zealandicus* and *P. setosus* as separate species, especially as the two names have already been used.

* Trans. N.Z. Inst., xxi., pp. 237–252, plate x.

† Proc. U. S. National Museum, vol. xx., pp. 643–694, with plates lxii.–lxx.

When Captain Hutton described *P. setosus* he had before him, as Faxon points out, specimens from the River Avon, Christchurch, and from Invercargill—*i.e.*, of *P. setosus (sensu strictiori)* and of *P. zealandicus*. His description, however, has evidently been drawn up from the River Avon specimens only, though the large specimen in the Otago Museum labelled *Paranephrops setosus* in Hutton's own handwriting, and therefore presumably a type specimen, proves to be a specimen of *P. zealandicus* from a different locality.

I give below brief abstracts of Faxon's descriptions of the three species, with the more important references only; the full references are given in Faxon's paper.

1. **Paranephrops planifrons,** White.

Paranephrops planifrons, White, Gray's Zoolog. Miscell. No. II., p. 79 (1842); Chilton, Trans. N.Z. Inst., vol. xxi., pp. 242, 249, pl. x., figs. 1–3 (1888); Faxon, Proc. United States Nat. Mus., vol. xx., p. 678 (1898).

Faxon speaks of this as a puzzling species. In specimens from Puriri Creek, a tributary of the Thames, from which White's type specimens were obtained, he says, "The rostrum tapers off into a long and sharp acumen, which overreaches the distal end of the antennular peduncle. Each side of the rostrum is armed with three teeth, which are produced into long spine-like points. . . . The antennal scale is long, and diminishes in width from the basal third to the tip; it exceeds the rostrum in length. The post-orbital ridge is interrupted between the two sharp spines with which it is armed. A median ridge runs along the gastric area, reaching forwards as far as the anterior pair of post-orbital spines, but not continued on the rostrum. There are two or three sharp spines on each side of the carapace, just behind the cervical groove, besides several more on the hepatic and pterygostomian regions. The areola is very short and broad—not much over one-third as long as the distance from the cervical groove to the tip of the rostrum. The abdominal pleuræ are bluntly angulated. The hand is long and narrow, its superior and inferior margins nearly straight, parallel, and armed with a double row of spines—those on the superior margin the longest. The inner and outer faces of the hand are convex, and sparsely armed with spines, the largest of which are disposed in a median longitudinal row on each face."

Specimens from Karaka, Manukau Harbour, are quite similar, but those from Lake Roto-iti and more southern localities "differ constantly in having a shorter rostral acumen, shorter lateral rostral teeth, shorter and broader antennal scale; the areola, or, in other words, the posterior section of

the carapace, is much longer, being nearly one-half as long as a line drawn from the cervical groove to the anterior end of the rostrum; the hand, too, is provided with shorter fingers, and the lower half of the hand is more heavily tuberculate both on the inner and outer faces."

Large specimens from Roto-iti and Napier have the sides of the carapace thickly set with blunt tubercles, which become spiny only on the hepatic and pterygostomian regions and along the cervical groove; but in similar large specimens from Nelson all the tubercles tend to assume the form of spines. Specimens from Wellington and Pelorus River, Marlborough, have the lateral rostral spines increased in number and reduced to short, blunt teeth, and the antennal scale short and broad, broadest at the middle, with very convex internal border, and thus vary in the direction of *Paranephrops zealandicus*.

As I have already shown in my previous paper, *Paranephrops planifrons* is widely distributed in the North Island, and also occurs in the north-west portion of the South Island, the most southerly locality from which it has been recorded being Greymouth.

2. **Paranephrops zealandicus**, White.

Astacus zealandicus, White, Proc. Zool. Soc. London, pt. 15, p. 123 (1847). *Paranephrops neo-zelanicus*, Chilton (in part), Trans. N.Z. Inst., xxi., p. 249 (1888). *Paranephrops zealandicus*, Faxon, Proc. United States Nat. Mus., vol. xx., p. 680 (1898).

In this species "the chela is much shorter and broader than in *P. planifrons*, and it is furnished with conspicuous dense tufts of silky hair, disposed in longitudinal rows. The upper margin of the hand is armed with a series of prominent spines, continued as a double row on the margin of the dactylus. The lower margin of the hand is furnished with a double row of shorter spinous teeth. The outer face of the hand is provided with a few tubercles, which seldom develope any spinous points; the inner face bears two longitudinal rows of short teeth. The rostrum is armed on each side with small, blunt teeth, usually five in number, but in some individuals three, four, or six; the inferior edge is either unarmed or else provided with one or two acute teeth; a median carina runs over the gastric area, ceasing abreast of the anterior pair of post-orbital spines, the rostrum proper being wholly destitute of a median dorsal keel. In small specimens the sides of the carapace are smooth, or at the most reveal only the slightest trace of low rounded papillæ; but in large specimens, that have attained a length of 115 mm. or more, the sides of the carapace are thickly studded with rounded tubercles. The

antennal scale is rather short, and it is broadest in the middle."

This species, as restricted by Faxon, appears to be common throughout Otago and Southland, and has been recorded also from Stewart Island.

In connection with this species, Faxon gives the result of some observations I had communicated to him on the variations in size, &c., that occur in correspondence with the quantity of water in which the crayfishes live. In small streams around Dunedin and Port Chalmers, where the flow of water is small, the specimens are all small, sexually mature specimens not exceeding 84 mm. in length, and in them the carapace is well-nigh destitute of spines and tubercles. In places where these streams have been dammed up to form reservoirs, such as the Dunedin reservoirs, or the small one connected with the Glendermid Tannery at Sawyer's Bay, the crayfish attain a much larger size, even up to 158 mm. in length, and in them the sides of the carapace are heavily tuberculated, the tubercles having the form of prominent, smooth, rounded papillæ.

If sexually mature specimens from the small streams and from the reservoirs are examined without knowledge of the conditions under which they occurred, they would almost certainly be considered as different species by the vast majority of systematists.

3. Paranephrops setosus, Hutton.

Paranephrops setosus, Hutton, Ann. Mag. Nat. Hist., 4th ser., xii., p. 402 (1873); Chilton, Trans. N.Z. Inst., xv., p. 150, pls. xix–xxi. (1882). *Paranephrops neo-zelanicus*, Chilton (in part), Trans. N.Z. Inst., xxi., pp. 246, 249, pl. x., figs. 1*a*, 2*a* (1888). *Paranephrops setosus*, Faxon, Proc. United States Nat. Mus., xx., p. 681 (1898).

Faxon regards this species as distinguished from *P. zealandicus* by the following characters: "The cephalothorax is more oval than in *P. zealandicus*, owing to the bulging of the sides of the carapace; the sides of the carapace are thickly strewn with acute, forward-turned spines, which take the place of the rounded tubercles in *P. zealandicus*. The rostrum and antennal scale are longer, the lateral rostral teeth longer and more spiniform; the rostrum is furnished with an evident median keel, most prominent on the distal half of the rostrum (in *P. zealandicus* there is a gastric keel, but no keel on the rostrum)."

The species as thus restricted has been recorded only from the Avon and Heathcote, at Christchurch, and from streams at Rangiora. The largest specimen examined was 145 mm. in length.

From the above account it will be seen that in the North Island there is only one species of fresh-water crayfish (which may, however, be divided into two or three fairly well marked varieties), while in the South Island there are three species.

ART. VI.—*Description of a New Species of* Halictus (Andrenidæ) *from Christchurch, New Zealand.*

By P. CAMERON.

Communicated by Captain Hutton.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1899.*]

Two species of *Halictus* have been recorded from New Zealand. These may be separated from the species here described as follows :—

A. Base of median segment bearing radiating striæ.
  Mandibles ferruginous; legs dark testaceous; abdomen fuscous; alar nervures ferruginous .. .. *sordidus*, Smith.
  Mandibles bright-yellow, black at base and apex; legs black; the knees and the greater part of the tarsi yellow; alar nervures fuscous .. .. .. *huttoni*, n. sp.
B. Base of abdomen finely rugose.
  Mandibles black, rufo-testaceous at the apex; legs black .. .. .. *familiaris*, Smith.

Halictus huttoni, sp. nov.

Niger, capite thoracique dense argenteo pilosis; apice clypei, labro, medio mandibularum late, geniculis basique tarsorum late, flavis; alis hyalinis, nervis nigro-fuscis. ♂. Long. 5 mm.

The basal three joints of the antennæ black; the rest brown, black above; the scape sparsely covered with long white hair; the flagellum with a close white down. Head black; the front duller in colour; the apex of the clypeus broadly, the labrum and the mandibles broadly in the middle, bright-yellow. The vertex has a slight greenish tinge, is more shining than the front, and is closely and finely punctured; the ocellar region smooth and shining; the front is opaque, alutaceous; both parts are thickly covered with long fuscous hair; the lower orbits, the clypeus, and labrum are thickly covered with long silvery pubescence. Thorax entirely black; the mesonotum shining, finely and closely punctured; a broad,

shallow furrow on the basal two-thirds in the middle. Scutellums finely punctured, and thickly covered with long white hair. Metathoracic area closely, irregularly striated, its apex smooth and shining; the apex has an oblique slope, is finely punctured, is widely furrowed in the middle, and is thickly covered with long white hair. Propleuræ shining, the middle furrow minutely striated; mesopleuræ alutaceous, thickly covered with long white hair; in the middle, at the base, is a shallow oblique furrow, the part above it being raised; the metapleuræ are finely rugose. Legs thickly covered with white hair; all the knees, the front tibiæ (except behind), the greater part of the anterior tarsi, and the four posterior tarsi broadly at the base bright-yellow; the spurs yellow. Wings clear hyaline; the stigma fuscous, the nervures darker; the first recurrent nervure is almost interstitial, being received immediately in front of the transverse cubital; the second recurrent nervure is received more distinctly in front of the third transverse cubital. Abdomen shining, thickly covered with a short white pubescence; aciculated; the depression on the basal segment is large, deep, triangular; the apical ventral segments have the apices testaceous; the penultimate segment is slightly normally incised; the others transverse. The pubescence on the abdominal segments does not form bands; the second and third are distinctly depressed at the base; the last is transverse at the apex; the lateral furrows are oblique, and reach near to the base.

The eyes distinctly converge below, and have, on the inner side above, a distinct semicircular curve; behind them the head is obliquely narrowed. The apex of the median segment has a distinct margin laterally, almost keeled. Mesosternum alutaceous, broadly but not deeply furrowed down the middle. The pronotum in the middle behind is depressed, and has there a short, distinct, longitudinal furrow; its base has a narrow but distinct margin.

I may take this opportunity of pointing out an important change in nomenclature. In "Notes on a Collection of *Hymenoptera* from Greymouth, New Zealand, with Descriptions of New Species,"* I described a new genus of *Ichneumonidæ*, founded on the species described by Mr. W. F. Kirby† under the name of *Rhyssa semipunctata*, which I called *Xenopimpla*. When doing so I had, however, unfortunately overlooked the fact that the genus had been already described by Dr. Kriechbaumer in "*Entomologische Nachrichten*," xv., p. 309, 1889, as *Lissopimpla*. It is grounded on three Aus-

* Mem. and Proc. of the Manchester Literary and Philosophical Society, 1898.

† Trans. Ent. Soc. of London, 1883, p. 202.

tralian species, all very similar in colouration and markings to the New Zealand species. I cannot make out to my satisfaction if Dr. Kriechbaumer has described Mr. Kirby's species, nor can I identify with any of them an Australian species in my own collection, this species showing considerable variation. The publication of Dr. Kriechbaumer's paper only affects the generic name, Mr. Kirby's specific name "*semipunctata*" being anterior by six years to the publication of the paper in which the German author described *Lissopimpla.* The name of the New Zealand species will therefore be *Lissopimpla semipunctata*, Kirby.

Captain Hutton informs me that his belief is that the species has been introduced into New Zealand from Australia. The evidence undoubtedly is that it was rare in New Zealand thirty years ago, while now it is not at all rare. At Greymouth the late Mr. Richard Helms took it commonly. It is probably, judging from its long ovipositor, a parasite on some wood-feeding insect. It varies considerably in size, as do other *Pimplidæ* which feed on wood-feeding insects.

The genus is, up to now at least, not known outside the Australian zoological region.

ART. VII.—*Notes on some New Zealand* Orthoptera.

By Captain F. W. HUTTON, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 20th August, 1899.*]

Lissotrachelus maoricus, Walker, Cat. Dermap. Salt. in Brit. Museum, p. 74 (*Scleropterus*).

I found this species not uncommon at Whangarei, among grass. It is related to *L. ater* of Borneo, but differs not only in specific characters but in others which might be considered as generic.

The antennæ are unicolor and not moniliform; the third joint of the palpus is clavate; the ovipositor is straight, and the metatarsus of the hind legs has a pair of apical spines as long as those of the tibia. The fore tibiæ are without auditory pits, and the lateral lobes of the pronotum are about as deep as long.

The following are additions to Walker's description: In both the male and the female the elytra are abbreviated, not reaching the end of the abdomen. They have seven longi-

tudinal nervures, without any transverse branches. The ovipositor is about the length of the cerci; it is slender, and curved upwards. The first joint (metatarsus) of the posterior tarsus has a pair of long apical spines.

Length, 7 mm.; pronotum, 1½ mm.; posterior femur, 5 mm.; ovipositor, 1½ mm.

Gryllodes maorius, Saussure, Melange Orthop., p. 377.

This species is put down to New Zealand by Saussure on the evidence of a specimen in the Berlin Museum. I have never seen it. The following is Saussure's description: "Reddish-fuscous, with grey tomentum; head fuscous, with a yellowish transverse band above the antennæ; lobes of the pronotum washed with testaceous. Elytra much shortened, covering the first abdominal segment, contiguous at their bases. Ovipositor shorter than the hind femora, the valves rather depressed, slightly acute. Mediastinal vein unbranched. Head globose, moderately broad between the antennæ. Pronotum rather flat above.

"Length, 13·5 mm.; pronotum, 2·4 mm.; hind femur, 8 mm.; ovipositor, 7 mm.; elytra, 3 mm. Width of pronotum, 7 mm."

The genus *Gryllodes* differs from *Gryllus* in having a narrower front between the antennæ. The auditory pit on the inner side of the fore tibia is generally absent. The mediastinal vein of the elytra is unbranched in the female, and singly branched in the male; the dorsal field of the female is longitudinally veined. In *Gryllus* the mediastinal vein has, generally, several branches, and the dorsal field of the female is, generally, rhomboidly reticulated.

Hemideina parva, Buller, Trans. N.Z. Inst., xxvii., 147 (*Deinacrida*).

I have examined the type of this species and find it very distinct, but it undoubtedly belongs to the genus *Hemideina*.

The anterior femur has no apical spines. The middle femur has an apical spine on the inner side, as also has the posterior femur, and the latter is armed below with eight strong teeth in the outer and seven in the inner row. The hind tibiæ above have five spines in the inner and four in the outer row. The middle tibia has two spines on the upper side, while below there are three in each row. The fore tibia has no spines above, and below there are four in each row. The pronotum is strongly roughened, the meso- and meta-nota slightly so. The abdominal terga are smooth; the second, as well as those following, is emarginate.

The two spines on the upper surface of the middle tibia place this species in a separate group from the others.

Hemideina broughi, Buller, Trans. N.Z. Inst., xxviii., 324 (*Deinacrida*).

An examination of the type in the Colonial Museum, at Wellington, showed me that it had very distinct apical spines on the middle and posterior femora, and that it is identical with my *H. ricta*. I was misled by Sir W. Buller's statement, "The four anterior femora free from spines."

Pleioplectron cavernæ, sp. nov. *Pachyrhamma edwardsii*, Brunner, Mon. Stenopelmatidæ, p. 58, not *H. edwardsii*, Scudder.

Joints of the antennæ cylindrical in both sexes. Fore and middle femora unarmed below; hind femora with five to seven spines below on the inner side and two minute ones on the outer in the male, but only four on the inner side and none on the outer in the female. Fore and middle tibiæ with three spines in each row. Hind tibiæ with from twenty-five to thirty spines in the outer, and twenty-two to twenty-eight in the inner row, small but regular, some of the proximal ones very minute. Subgenital plate of the male with a lanceolate projection between the bases of the styles; not keeled.

Length of pronotum, ♂ 6 mm., ♀ 5 mm.; of thorax, ♂ 13 mm., ♀ 12 mm.; of abdomen, ♂ 20 mm., ♀ 16 mm.; of fore tibia, ♂ 14 mm., ♀ 11 mm.; of hind tibia, ♂ 34 mm., ♀ 20 mm.; of hind femur, ♂ 27 mm., ♀ 18½ mm.; of antennæ, ♂ 93 mm., ♀ 55 mm.

Collected by Mr. R. M. Laing in a small cave near the Karapiti fumarole, Taupo.

Colour brown, spotted with yellowish-brown. Legs yellowish-brown, the femora banded with brown. The colours are variable, no two specimens having the same markings.

This species is easily distinguished from the others belonging to the genus by the greater number of spines on the lower surface of the hind femur. Described from four males and two females.

The type of *Pachyrhamma* is by description *Pleioplectron cavernæ*, but by figure it is *Pachyrhamma fascifer;* consequently, I suppose that I am at liberty to select one or the other. I take the figure of *P. fascifer* (= *novæ-zealandiæ*) as the type, for to do otherwise would entail the making of a new generic term for it.

Art. VIII.—*Note on* Paryphanta lignaria.

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 20th August, 1899.*]

Plate II.

Sir Walter Buller has kindly allowed me to photograph a perfect shell of this species which was obtained on Mount Rochfort, near Westport, and to add to the description given in the "Transactions of the New Zealand Institute," vol. xx., p. 43. The greatest diameter is about 2 in. There are five and a half whorls in the specimen, and the angle of spire is 125°. The whole shell is of a yellowish-brown or luteous colour, the brown bands being obsolete. The first whorl is pale, the following ones are darker in colour. The umbilicus is the same as in *P. hochstetteri*. The aperture is transverse, the columella descending more than in the adult *P. hochstetteri*, but not so much as in the young of the same species. The peristome is thin, the upper margin oblique, slightly undulated near the suture.

The figures (Plate II.) are rather less than natural size; the lower one is slightly canted to get the light into the umbilicus, so that it does not show the correct outline at the base. This is seen in the upper figure. I have compared this specimen with photographs of the types of *Paryphanta gilliesii* kindly sent to the Museum by Mr. E. A. Smith, and I find that that species has a much larger umbilicus than *P. lignaria*, besides being flatter.

Art. IX.—*The* Tipulidæ, *or Crane-flies, of New Zealand.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 1st November, 1899.*]

Plates III. and IV.

This paper is founded on Mr. G. V. Hudson's collection, which he kindly sent me to describe. As it raises the list of our *Tipulidæ* from nineteen to forty-four species, the collection must be considered a very good one, and I hope that I shall be found to have given a fairly good account of it. My part, however, has been rendered comparatively easy by Mr.

Skuse's papers on the Australian *Tipulidæ*, in the "Proceedings of the Linnæan Society of New South Wales" for 1889 and 1890, and by Baron Osten-Sacken's "Studies," which he was good enough to send me.

All the New Zealand species of *Tipulidæ* as yet described are endemic, while all the genera except two—*Tinemyia* and *Tanyderus*—are found in Australia, and it is probable that these two will be found there in due course. *Tanyderus* is found in Chili and Amboina; *Macromastix* in Australia and Chili; *Gynoplistia* is limited to Australia, New Guinea, and Celebes; and *Cerozodia* to Western Australia. The other twelve genera have a wide distribution.

Family TIPULIDÆ.

Legs very long and slender. The head prolonged forwards into a rostrum, which is often provided with a sharp-pointed nasus. Ocelli nearly always absent. Mesonotum generally with a V-shaped transverse suture. The basal cells of the wings elongated, almost always reaching beyond the middle of the wing; a discal cell in most of the genera. Ovipositor generally with two pairs of horny pointed valves.

KEY TO THE SUB-FAMILIES.

V-shaped suture distinct.	
Auxiliary vein ends in the first longitudinal, or absent	*Tipulinæ.*
Auxiliary vein ends in the costa	*Limnobinæ.*
V-shaped suture, indistinct or absent..	*Ptychopterinæ.*

Sub-family TIPULINÆ.

The tip of the auxiliary vein turns backwards and joins the first longitudinal; sometimes it is blended with the first longitudinal, and therefore apparently absent. No subcostal cross-vein. The first longitudinal ends in the second, and is connected near its tip to the costa by a cross-vein. Last joint of the palpi long and flagelliform, generally longer than the other three taken together.

KEY TO THE NEW ZEALAND GENERA.

No discal cell	*Dolichopeza.*
A discal cell.	
Second posterior cell sessile	*Pachyrhina.*
Second posterior cell petiolate.	
No tubercle above the antennæ	*Tipula.*
A tubercle above the antennæ	*Macromastix.*

Genus DOLICHOPEZA, Curtis (1825).

"Anterior branch of the second longitudinal vein entirely wanting, consequently there is no rhomboid cell. Præfurca extremely short, often almost vertical. Discal cell wanting;

the chief cross-vein situated a considerable distance before the base of the fourth posterior cell. Antennæ 13-jointed. Genitalia of the male somewhat incrassate, with long digitiform appendages" (Skuse).

Dolichopeza atropos. Plate III., fig. 1.

Tipula atropos, Hudson, Trans. N.Z. Inst., vol. xxvii., p. 295 (1895).

Uniform dark-brown, the wings tinted yellowish-brown; the stigma and veins brown. The third joint of the antennæ is elongated, and is as long as the fourth and fifth taken together. Second posterior cell rather short, petiolate; chief cross-vein more than half its length distant from the end of the fourth posterior cell. The auxiliary vein joins the first longitudinal at the origin of the second longitudinal. The first longitudinal ends free, and there is no marginal cross-vein. The third longitudinal is much bent down, and then turns slightly upwards before joining the margin of the wing. Anal angle of the wing distinct.

Male.—Length of body, 12 mm.; of wing, 15 mm.

Hab. Wellington (Hudson).

The male forceps is incrassate, but I cannot make it out clearly without destroying the unique specimen.

Genus Pachyrhina, Macquart (1889).

Rostrum short and stout. Antennæ generally 13-jointed, about the length of the thorax. Second posterior cell sessile.

Pachyrhina hudsoni. Plate III., figs. 2*a* to 2*d*.

Tipula dux, Hudson, Trans. N.Z. Inst., vol. xxvii., p. 293 (1895), not of White and Kirby (1884).

In this fine species the rostrum is stout, about the length of the head, and the terminal joint of the palpi is long and flagelliform. The antennæ are 13-jointed; the first joint long and cylindrical, the second globular, the third, fourth, and fifth cylindrical, stout, decreasing in length, the rest very narrow, with long hairs; the thirteenth joint minute. Wings luteous, with a pale, irregular, transverse fascia from the tip of the first longitudinal, across the chief cross-vein, as far as the fourth longitudinal; also a pale spot on the posterior margin of the discal cell. The discal cell is large, pentagonal, receiving the posterior cross-vein at its outer posterior angle. Præfurca longer than the chief cross-vein, forming about one-half of the second longitudinal. Forceps of the male exposed, not thickened, formed by two pairs of appendages, an upper and a lower. The upper pair, or forceps proper, 2-jointed; the basal joint long and oval in shape, the

second joint small, the inner edge slightly dentate and ending in a minute, dark, horny tooth. The lower pair smaller, claw-shaped, with a free lobe on the inner side. Ovipositor long and pointed. Length, ♂ 28 mm., ♀ 38 mm.; wing, ♂ 30 mm., ♀ 31 mm.; antennæ, ♂ 3 mm., ♀ 3 mm.

Hab. Wellington (Hudson).

Although this species has a short rostrum, a sessile second posterior cell, and a long terminal joint to the palpi, it is not a true *Pachyrhina*, on account of the position of the posterior cross-vein and the long præfurca, in both of which it resembles *Tipula*. As, however, there appear to be several other species intermediate between these two genera, it will be advisable to retain ours in *Pachyrhina* until a revision is made by some one who can examine a large collection from all parts of the world.

The antennæ and male forceps appear to be peculiar, unless in the latter the lower pair of appendages are the "large foliaceous appendages" described as occurring in *Longurio*.

Genus TIPULA, Linnæus (1740).

Rostrum longer than the head, with a distinct nasus. Antennæ simple, short in both sexes. Terminal joint of the palpi long and flagelliform. Discal cell receiving the posterior cross-vein at its outer posterior angle; second posterior cell petiolate; second longitudinal vein not sinuated. Genitalia protruding in both sexes; forceps of the male moderately thickened.

The species *novaræ* and *fulva* form a section which has perhaps as much claim to generic distinction as has *Holorusia*. Also *orion*, *dux*, *clara*, and *tenera* form another group of closely allied species.

KEY TO THE SPECIES.

Third longitudinal vein sinuated.
- Wings clear, with a few small spots .. .. *T. novaræ.*
- Wings yellowish, with a dark spot on the chief cross-vein .. .. *T. fulva.*

Third longitudinal vein not sinuated.
- Præfurca short, less than one-third of second longitudinal vein.
  - Greenish, no pale ring behind the eyes .. *T. viridis.*
  - Brown, a pale ring behind the eyes.. .. *T. obscuripennis.*
- Præfurca long, nearly half of second longitudinal vein.
  - Costal cell dark-brown.
    - Wings ochraceous .. .. .. *T. orion.*
    - Wings hyaline.
      - Tips of the wings clear .. .. *T. dux.*
      - Tips of the wings fuscous .. .. *T. clara.*
  - Costal cell clear .. .. *T. tenera.*

Tipula novaræ.

Tipula novaræ, Schiner, Reise der "Novara," Diptera, p. 37 (1868); Cat. Dipt. of N.Z., p. 14. *Tipula senex*, White and Butler, Voy. "Erebus" and "Terror," Insects, p. 27, pl. vii., fig. 15 (1875); Cat. Dipt. of N.Z., p. 14: Kirby, Trans. Ent. Soc. of London, 1884, p. 270.

As Mr. Kirby has pointed out, the colours of the body of this insect are very variable, and the darker varieties are nearly unicolor. In both Schiner's and White's descriptions mistakes occur in describing the four spots on the wings. They are as follows: The first is at the base of the anterior basal cell; the second is on the anterior margin of the posterior basal cell, at about half its length, where a short spurious vein runs down; the third is at the origin of the second longitudinal vein; while the fourth is at the apex of the first marginal and base of the second submarginal cells. Also a brown band runs from the fourth spot along the chief cross-vein, the base of the discal cell, and the posterior cross-vein, to the tip of the fifth longitudinal vein. Schiner is also incorrect in saying that the joints of the antennæ are "totally bare," for they have the usual short hairs. The forceps in the male is not thickened. The ovipositor is long and pointed. Length, ♂ 16–18 mm., ♀ 25 mm.; of wing, ♂ 21–22 mm., ♀ 27 mm.

Hab. Throughout New Zealand.

Walker, in his "List of Diptera in the British Museum," p. 71, gives New Zealand and New South Wales as localities for this species, but the latter is probably a mistake, as Mr. Skuse does not know the insect.

In both this and the next species the venation is remarkable, in that the chief cross-vein arises at the end of the præfurca, so that the second submarginal cell has only a punctiform contact with the anterior basal cell. The third longitudinal is in a line with the præfurca, and bends upwards towards the posterior branch of the second longitudinal, and then down again to the margin.

Tipula fulva, sp. nov. Plate III., fig. 3.

Rostrum with a distinct nasus. Antennæ short, 13-jointed, simple. Body nearly uniform reddish-yellow, the thorax with yellowish longitudinal bands. Wings yellowish, getting dusky towards their tips; a fuscous spot at the bases of the second submarginal and first posterior cells, inside of which is a transparent fascia extending from the costa through the first submarginal and anterior basal cells, to the discal. Fifth posterior and axillary cells also nearly clear; seventh longitudinal vein margined with fuscous; a small dark spot at the

origin of the second longitudinal vein. Short cross-folds in the costal cell and along the hind margin of the posterior basal cell. Length, ♂ 20 mm.; wing, ♂ 22 mm. Female not known.

Hab. Nelson (Hudson).

The venation of the wing resembles that of *T. novaræ.* The præfurca is about equal in length to the third longitudinal.

Tipula viridis. Plate III., figs. 4*a*, 4*b*.

Tipula viridis, Walker, Ins. Saunders, Diptera, p. 445 (1856).
T. holochlora, Nowicki, Mem. d. Krakauer K.-K. Akad. der Wissenchafften, band 2, gedructen Aufsatzes (1875); Cat. Dipt. of N.Z., p. 15: Hudson, Manual of N.Z. Entomology, p. 47, pl. v., figs. 1 and 1*b*.

Greenish luteous. Thorax testaceous above, with three longitudinal darker bands, the central of which is the shortest, and is sometimes divided into two bands. Wings hyaline, without spots; the costal cell and stigma pale-yellowish. Length, ♂ 15 mm., ♀ 22 mm.; wing, ♂ 21 mm., ♀ 28 mm.

Hab. Throughout New Zealand.

The antennæ are rather longer and slenderer than usual; the ninth to the eleventh joints being markedly narrower than those that go before them; the twelfth joint is rather thicker, forming a slight club; the thirteenth is minute. In the wing the præfurca is short, forming only about a fourth of the whole of the second longitudinal vein. The petiole of the second posterior cell is short. The forceps of the male is thickened. The ovipositor is long and pointed.

Tipula obscuripennis. Plate III., fig. 5.

Tipula obscuripennis, White and Kirby, Trans. Ent. Soc. of London, 1884, p. 271.

Male.—"Reddish-brown above, with a greyish bloom beneath. Head reddish-brown, with a white ring round the black eyes. Thorax greyish, with two contiguous reddish-brown stripes occupying the middle above; they are divided by a narrow pale line, and are slightly narrower behind than before; on each side is a darker oval spot, which is continued on to the metathorax. This and the scutellum are pale and shining, the latter edged with dusky behind. Abdomen reddish-brown above, with an obsolete dark spot in the middle of each segment; second segment almost entirely dusky. Legs tawny, with the knees and tarsi blackish. Wings hyaline, with the costal cell and the rather large oblong stigma pale-yellow; halteres blackish; a transparent space in the costal cell, and the lower part of the hinder basal cell with small perpendicular folds" (Kirby). Forceps thickened.

Female with degenerate wings, unable to fly. Ovipositor quite short and thick. The abdomen often rugose.

Length, ♂ 7–9 mm., ♀ 10 mm.; wing, ♂ 14–16 mm., ♀ 4 mm.

Hab. Auckland to Christchurch.

I give Mr. Kirby's description in full, but the colours of the thorax and abdomen vary a good deal, many specimens being unicolor. It can, however, always be recognised by the pale ring behind the eye. The antennæ are rather short and stout. The wings are slightly smoky, except a transparent mark on both sides of the stigma. The præfurca is short, forming less than a third of the second longitudinal vein; the petiole of the second posterior cell is long. The auxiliary vein is more or less blended with the first longitudinal.

The eggs are laid in the ground, and the adult insect emerges in April.

Tipula dux. Plate III., fig. 6.

Tipula dux, White and Kirby, Trans. Ent. Soc. of London, 1884, p. 270.

"Orange; head orange; antennæ, palpi, and most of the upper surface of the muzzle (which is moderately broad, obtuse, and set with short stiff bristles) blackish; base of palpi brown, a long black streak running forwards to a double point from the middle of the vertex. Thorax orange; front of prothorax and first pleural sutures black; a wide black stripe on the back of the mesothorax, ceasing before the lateral suture, and with a brown extension on each side in front; and two wide black stripes on each side, starting at about one-fourth of the length of the mesothorax, and curving towards each other, but not meeting, on the scutellum, which is wholly orange. Abdomen orange, with a black stripe on the back widened at the extremity of each segment, a black stripe on each side, and a central one (paler towards the base of the abdomen) beneath; legs black; front femora yellowish beneath. Wings hyaline, naked, iridescent, with short folds along the outer half of the upper edge of the front basal cell and along the lower edge of the hind basal cell; veins brown; costal cells and stigma yellowish-brown; first marginal and first submarginal cells clear; a triangular dusky spot extending to the inner side of the basal cross-vein; halteres yellow, with the clubs black" (Kirby). Length, ♂ 15 mm.; wings, ♂ 19–20 mm. The female is unknown.

Hab. Auckland and Wellington (Hudson).

In none of my specimens is there a dark mark on the vertex. The stigma and costal cell as far as the basal cross-vein are dark-brown; inside the basal cross-vein the costal cell is clear. The auxiliary is completely blended with the

first longitudinal vein. The præfurca is long, forming nearly one-half of the second longitudinal vein; the petiole of the second posterior cell is moderate, but variable in length; the fifth longitudinal is distinctly double. The legs are rather stout. The antennæ are 13-jointed, rather short and stout. The first joint is large and cylindrical, the second cyathiform; the others slightly oval, decreasing in length; the twelfth is swollen to form a small club, the thirteenth is minute. The forceps of the male is thickened.

Tipula orion.

Tipula orion, Hudson, Trans. N.Z. Inst., vol. xxvii., p. 294 (1895).

This species is closely related to *T. dux*, but the wings are of a decided ochraceous tint; also, there is always a fuscous elongated spot on the vertex between the eyes. The basal joint of the antennæ is orange. The tip only of the rostrum is fuscous. The pronotum is entirely orange; the mesonotum has the usual dark bands, which are sometimes fused together. The triangular spot at the basal cross-vein is less distinct than in *T. dux*. Length, ♂ 13–14 mm.; wing, ♂ 18–19 mm. Female unknown.

Hab. Mountains of Nelson, 4,000 ft. above the sea (Hudson).

Tipula clara.

Tipula clara, White and Kirby, Trans. Ent. Soc. of London, 1884, p. 271.

"Head and thorax orange-yellow; antennæ, except the long basal joint, palpi, tip of muzzle, and a spot between the eyes dusky; palpi set with short bristles. Abdomen black, with a stripe on each side, the incisions and anus yellow; coxæ yellow; legs brown, under-surfaces shading into yellowish. Wings nearly as in *T. dux*, but without longitudinal folds; the apex is clouded, and the triangular spot on the basal cross-vein is smaller and more sharply defined; halteres yellow, with black tips" (Kirby). Length, ♂ 10 mm.; wing, ♂ 16 mm. Female unknown.

Hab. Auckland and Wellington (Hudson).

The antennæ and the venation of the wings resemble those of *T. dux*, but the legs are more slender.

Tipula tenera, sp. nov.

Pale yellow-orange. Palpi, tip of the rostrum, and the antennæ (except the first joint) fuscous, as also is a narrow longitudinal line on the tip of the head between the eyes. Pronotum with some dark spots in the middle. Mesonotum black, divided by light lines at the sutures; scutellum yellow;

metanotum yellow, with two black spots near the posterior margin. Abdomen with black lateral stripes, which meet, both above and below, on the penultimate segment, so that the two last segments are altogether black. Forceps of the male thickened, hidden. Legs slender, black, the coxæ yellowish-orange. Wings hyaline, the costal cell clear; stigma brown; the lower edge of the posterior basal cell with small folds. Length, ♂ 9 mm.; wing, ♂ 12–13 mm. Female unknown.

Hab. Wellington (Hudson).

Genus Macromastix, Osten-Sacken (1886).

Rostrum rather long, with a distinct nasus. Last joint of the palpi about as long as the other three taken together. Front with a tubercle above the antennæ. Antennæ of male 13-jointed, often much longer than the body, sometimes short; first joint thickened, the second short, the others almost filiform; the joints gradually increasing in length. Antennæ of female 13-jointed, not longer than the head. Abdomen rather stout and short; the last segment in the male narrower than the others; the forceps small and not protruding. Ovipositor not protruding. Tibiæ with spurs; empodia present. Venation of the wings as in *Tipula*.

This genus is the same as *Macrothorax* of Jaennicke (1867), a name which had been preoccupied in 1864.

Key to the Species.

Wings unspotted.	
Wings colourless.	
Thorax cinerous, very hairy	***M. vulpina.***
Thorax yellowish, glabrous	***M. pallida.***
Wings tinted.	
Thorax cinerous, not very hairy	***M. fucata.***
Thorax black, with yellow hairs	***M. montana.***
Wings spotted.	
Pale marks in basal cells connected	***M. lunata.***
Pale marks in basal cells separated	***M. binotata.***

Macromastix vulpina.

Megistocera vulpina, Hutton, Cat. Diptera of N.Z., p. 16 (1881). *Macromastix vulpina,* Osten-Sacken, "Studies on Tipulidæ," part i., p. 185.

This species is easily distinguished by the long yellowish-white hairs on the chest. The præfurca occupies about one-third of the whole of the second longitudinal vein. The auxiliary vein is blended with the first longitudinal. The hind margin of the posterior basal cell has a series of small cross-folds. Length, ♂, ♀ 9–10 mm.; of the wing, ♂, ♀ 15 mm.; of the antennæ, ♂ 19–20 mm., ♀ 3 mm.

Hab. Otago (F. W. H).

Macromastix fucata, sp. nov.

Head, rostrum, and bases of the antennæ yellowish-brown; occiput, palpi, and tips of the antennæ fuscous. Pronotum, scutellum, and part of the metanotum yellow. Mesonotum cinerous, the transverse suture black; four dusky bands before the suture, the middle pair not reaching the anterior margin, united both before and behind, the exterior pair shorter; pleuræ and pectus cinerous, not very hairy. Halteres fuscous. Abdomen cinerous, except the second segment. Second to sixth segments with a black dorsal mark, contracted forwards on each segment. On the second segment this mark is bordered on both sides and in front with dull-yellow. The third to the sixth segments are narrowly margined behind with yellow; the seventh and eighth segments have a parallel-sided black mark on the dorsum; the ninth segment is black. Wings tinted yellowish-brown, the costal cell yellower; stigma and veins brown. Coxæ cinerous; femora yellowish-brown except the tips, which, with the tibiæ and tarsi, are fuscous. Length, ♀ 15 mm.; wing, ♀ 18 mm.; antennæ, ♀ 3 mm. The male is unknown.

Hab. Wellington (Hudson).

Macromastix pallida, sp. nov.

Pale brownish-yellow, with faint brownish longitudinal bands on the mesonotum, and the distal halves of the fourth to the eighth abdominal segments brownish. Wings nearly colourless, the stigma and veins pale brownish-yellow. Petiole of the second posterior cell not so long as the cell. Intercalary vein bending slightly upwards, towards the anterior branch of the fourth longitudinal. Præfurca short, about one-fourth of the whole of the second longitudinal vein. Length, ♂ 14 mm.; wing, ♂ 18 mm.; antennæ, ♂ 18 mm. or 19 mm. The female is unknown.

Hab. Wellington (Hudson).

Macromastix montana, sp. nov.

Head and thorax black, with yellow hairs. Abdomen in the male reddish, with a dark dorsal band; in the female black, with the lower surface and nearly the whole of the second segment orange. Tubercle on the head rather small. Antennæ in both sexes not much longer than the head. Wings slightly smoky; uniform in colour, except the stigma, which is darker. Hind margin of the posterior basal cell with short transverse folds. Præfurca rather less than one-third of the second longitudinal vein; petiole of the second posterior cell short. Legs black, the proximal halves of the femora

orange. Length, ♂ 13–14 mm., ♀ 15–16 mm.; wing, ♂ 22–23 mm., ♀ 22 mm.; antennæ, ♂ and ♀ 3 mm.

Hab. Humboldt Mountains, Otago (Hudson).

Macromastix lunata, sp. nov.

Reddish-brown, the female paler than the male. Head between the eyes dusky. Mesonotum with four dark bands. Abdomen with a dark longitudinal dorsal band. Antennæ long in the male, short in the female; reddish at the base and gradually darkening outwards. Wings smoky, the anterior half darker than the posterior; stigma darker still. A large white lunate mark, convex backwards, in the basal cells; generally another clear space encircling the stigma. Hind margin of the posterior basal cell with short transverse folds. Præfurca forming more than one-third of the second longitudinal vein. Legs dark, the proximal halves of the femora and the coxæ reddish. Length, ♂ 9–10 mm., ♀ 10–11 mm.; wing, ♂ 15–16 mm., ♀ 17–18 mm.; antennæ, ♂ 25 mm., ♀ 3 mm.

Hab. Wellington (Hudson).

Macromastix binotata, sp. nov. Plate III., fig. 7.

Brownish-yellow, except the mesonotum, which is cinerous and with four brown bands, all of which are united on the fore border and taper backwards. The palpi and the dorsi of the third to the eighth abdominal segments dusky. Halteres yellowish, the tips paler. Wings dusky, with darker clouds at the apex of the first submarginal cell and along the anterior edge of the fifth longitudinal vein. A clear fascia runs from the base of the first submarginal cell across the basal cells; another lies near the basal cross-vein. Petiole of the second posterior cell short, less than one-half of the length of the cell. Intercalary vein sinuated, and bent backwards near its tip towards the fifth longitudinal. Præfurca between one-half and one-third of the whole length of the second longitudinal vein. Length, ♂ 12 mm.; wing, ♂ 17 mm.; antennæ, ♂ 9 mm. The female is unknown.

Hab. Wellington (Hudson).

Sub-family LIMNOBINÆ.

The tip of the auxiliary vein turns forward and ends in the costa. A subcostal cross-vein nearly always present. Last joint of the palpi short, not longer than the two preceding joints.

KEY TO THE NEW ZEALAND GENERA.

Tibiæ without spurs; eyes approximated.
- One submarginal cell.
  - No marginal cross-vein .. .. .. *Rhamphidia.*
  - A marginal cross-vein.
    - Auxiliary ends near the origin of second longitudinal.
      - Rostrum shorter than the head and thorax .. .. *Dicranomyia.*
      - Rostrum longer than the head and thorax .. .. *Geranomyia.*
    - Auxiliary ends much beyond the origin of the second longitudinal.
      - Sixth and seventh longitudinals connected by a cross-vein .. .. *Trochobola.*
      - Sixth and seventh longitudinals not connected .. .. .. *Limnobia.*
- Two submarginal cells.
  - Præfurca ends in the first submarginal cell .. *Molophilus.*
  - Prefurca ends in the second submarginal cell.
    - Three last joints of the antennæ abruptly smaller .. .. *Trimicra.*
    - Three last joints of the antennæ like the others .. .. *Gnophomyia.*

Tibiæ with apical spurs; eyes widely separated; two submarginal cells.
- Antennæ simple.
  - Rostrum not elongated .. .. .. *Limnophila.*
  - Rostrum much elongated .. .. .. *Tinemyia.*
- Antennæ uni-pectinate, ♂, or serrate, ♀.
  - Antennæ 16- to 22-jointed .. .. .. *Gynoplistia.*
  - Antennæ 32- to 39-jointed .. .. .. *Cerozodia.*

Genus DICRANOMYIA, Stephens (1829).

"One submarginal and four posterior cells; marginal cross-vein at the tip of the first longitudinal; tip of the auxiliary vein generally opposite or before the origin of the second longitudinal, seldom beyond it. Antennæ 14-jointed. Rostrum not longer than the head. Tibiæ without spurs. Empodia indistinct or none. Male forceps formed by two movable, soft, fleshy, subreniform lobes, and a horny style under them" (Osten-Sacken).

A. Wings with spots.

Dicranomyia vicarians.

Limnobia vicarians, Schiner, Reise der "Novara," Diptera, p. 46 (1868); Cat. Dipt. of N.Z., p. 17. *Dicranomyia vicarians*, Mik, Verh. z.-b. Wien, xxxi., p. 196, pl. xiii., fig. 1 (1881). *Limnobia chorica*, White, MSS.

Rust-red, with yellow legs. Wings pale-yellow, with a small spot at the origin of the second longitudinal and a larger one on the edge. Length, 5–6 mm.

Hab. Auckland. Unknown to me.

Dicranomyia fasciata, sp. nov.

Greyish-brown; coxæ and lower surface lighter. Wings hyaline; a large fuscous spot near the middle of the anterior basal cell, just inside the origin of the second longitudinal vein, another in the centre of the marginal cell, and a small spot at the origin of the third longitudinal vein. Inner and outer margins of the discal cell and the posterior cross-vein bordered with fuscous. The auxiliary vein ends slightly outside the origin of the second longitudinal; the posterior cross-vein lies inside the base of the discal cell. Rostrum shorter than the head. Joints of the flagellum submoniliform. Length, ♀ 7 mm.; wing, ♀ 9 mm. The male is unknown.

Hab. Christchurch (F. W. H.).

B. Wings without spots.

Dicranomyia monilicornis, sp. nov. Plate III., fig. 8.

Dicranomyia monilicornis, Osten-Sacken, MSS.

Yellowish-brown; rostrum, coxæ, and lower surface of body lighter; antennæ and palpi darker. Wings unspotted, slightly fuscous; the costa yellowish-brown; veins fuscous. Rostrum about the length of the head in the female, shorter in the male. Flagellum of the antennæ submoniliform in both sexes. Legs hairy. The auxiliary vein ends some distance inside the origin of the second longitudinal; posterior cross-vein in a line with the base of the discal cell. Length, ♂ 6–7 mm., ♀ 6–7 mm.; wing, ♂ 8–9 mm., ♀ 9 mm.

Hab. Christchurch (F. W. H.).

Dicranomyia nigrescens, sp. nov.

Dark-fuscous, almost black, the ovipositor reddish. Wings unspotted, dark-fuscous. Rostrum about as long as the head in the female. Joints of the flagellum of the antennæ oval. Auxiliary vein ending slightly beyond the origin of the second longitudinal. Posterior cross-vein in a line with the base of the discal cell. Length, ♀ 8 mm.; wing, ♀ 11 mm. The male is unknown.

Hab. Wellington (Hudson).

Genus Geranomyia, Haliday (1833).

"One submarginal cell; four posterior cells; a discal cell. Antennæ 14-jointed, submoniliform, joints not pedicelled. Rostrum and proboscis prolonged, longer than the head and thorax taken together; the short palpi inserted about their middle. Feet slender; tibiæ without spurs at the tip; empodia indistinct or none; ungues with teeth on the under-side. The forceps of the male like that of *Dicranomyia*" (Osten-Sacken).

Geranomyia annulipes, sp. nov. Plate III., figs. 9*a*, 9*b*.

Brownish-yellow; pronotum, a central band on the mesonotum, and metanotum fuscous. Proboscis about as long as the thorax without the head; palpi rather long, 4-jointed, situated at the middle of the proboscis. Antennæ 14-jointed; joints of the flagellum pyriform. Halteres with fuscous tips. The second to the seventh abdominal segments dark-brown above, with pale-yellowish hind margins. Legs brownish-yellow, with fuscous articulations and a fuscous ring near the tip of each femur. Wings tinted yellowish, with two large brown spots, the first at the origin of the second longitudinal vein, the second on the marginal cross-vein; also two small spots—one on the basal cross-vein, the other at the commencement of the submarginal cell. The chief cross-vein, the posterior cross-vein, and both inner and outer edges of the discal cell are bordered with fuscous. The tip of the auxiliary vein ends a little beyond the origin of the second longitudinal. Præfurca bent down and angled, with a small stump at the angle. Length, ♂ 6 mm.; wing, ♂ 8 mm. Female unknown.

Hab. Wellington (Hudson).

I place this species in *Geranomyia* on account of its long proboscis, but the antennæ do not agree with the definition of the genus. The posterior cross-vein lies inside the base of the discal cell.

Genus LIMNOBIA, Meigen (1818).

"One submarginal cell; four posterior cells; a discal cell. The marginal cross-vein is sometimes at the tip of the first longitudinal vein, but often at some distance anterior to this tip, crossing the stigma; the tip of the auxiliary vein is usually far beyond the origin of the præfurca. Antennæ 14- (often apparently 15-) jointed. Legs comparatively strong; tibiæ without spurs at the tip; empodia indistinct or none; ungues with several teeth on the under-side, giving them a pectinate appearance. The forceps of the male consists of two horny movable hooks, and a horny style under them" (Osten-Sacken).

Limnobia fumipennis.

Tipula (Cylindromata) fumipennis, White, MS. *Limnobia fumipennis*, Butler, Cistula Entomologica, vol. i., p. 355 (1875).

"Head and thorax dark-brown; abdomen dark-brown, with a widish pale line at the base in the middle; legs black; wings blackish, the veins at the end margined with deeper black than the general surface of the wings" (White).

Hab. New Zealand.

Limnobia conveniens.

Limnobia conveniens, Walker, List of Diptera in the Brit. Mus., p. 57 (1848); Cat. N.Z. Diptera, p. 17.

A small pale species with unspotted wings which is unknown to me. The fifth longitudinal vein is said, "beyond half its length, to send forth a branch which is forked."

Genus TROCHOBOLA, Osten-Sacken (1868).

"One submarginal cell; four posterior cells; a discal cell; the tip of the auxiliary is far beyond the origin of the second longitudinal vein; the marginal cross-vein is some distance anterior to the tip of the first longitudinal vein; a supernumerary cross-vein connects the sixth and seventh longitudinal veins. Antennæ 14-jointed. Legs slender; tibiæ without spurs at the tip; empodia indistinct; ungues with teeth on the under-side" (Osten-Sacken).

KEY TO THE SPECIES.

Wings with ocellated spots	*T. variegata.*
Spots on the wings not ocellated.	
Discal cell regular	*T. ampla.*
Discal cell irregular	*T. picta.*

Trochobola variegata, sp. nov.

Yellowish-brown; mesonotum with three narrow brown stripes; scutellum and centre of the metanotum dark-brown. Legs dark-brown; knees and a ring near the distal ends of the femora pale. Wings yellowish, with irregular, brown, ocellated markings, one round the origin of the second longitudinal, another round the marginal cross-vein, another at the outer edge of the discal cell, another round the supernumerary cross-vein, another at the tip of the sixth longitudinal, besides several irregular markings. First longitudinal vein arcuated near the marginal cross-vein, and joining the costa almost at right angles to it. Posterior cross-vein in a line with the inner margin of the discal cell. Joints of the flagellum of the antennæ oval. Length, ♂ 10 mm.; wing, ♂ 14 mm. The female is unknown.

Hab. Wellington (Hudson).

Trochobola ampla. Plate III., fig. 10.

Tipula fumipennis, Hudson, Man. of N.Z. Entomology, p. 48, pl. v., fig. 2; no description.

Brown; the legs yellowish, with a brown band near the tip of each femur. Thorax with some indistinct pale stripes. Wings pale yellowish-brown; a dark spot at the base of the anterior basal cell; a brown transverse fascia from the costa, through the origin of the second longitudinal, to the supernumerary cross-vein. Apex of wing beyond the basal cells

brown; a clear round spot in the base of the submarginal cell, and a clear space occupying most of the first posterior and discal cells. First longitudinal vein arcuated, but joining the costa obliquely. Posterior cross-vein in a line with the inner margin of the discal cell. Joints of the flagellum of the antennæ slightly cyathiform in the male, oval in the female. Length, ♂ 14 mm., ♀ 11 mm.; wing, ♂ 20 mm., ♀ 14 mm.

Hab. Wellington (Hudson).

I have not adopted Mr. Hudson's name for this species, because the wings are not smoky, and because we have already in New Zealand a *Limnobia fumipennis* which might cause confusion.

Trochobola picta, sp. nov. Plate III., fig. 11.

Yellowish-brown, darker below; mesonotum pale, with a narrow dark central line and a broader one on each side, passing from the head to above the wings; the tip of the scutellum and the metanotum dark-brown. Legs pale, with a dark ring near the distal end of each femur. Wings transparent, with numerous dark-brown spots; three near the costa. Of these the first is situated at the base of the anterior basal cell, the second at the origin of the second longitudinal vein, and the third round the stigmatic area; the latter is the largest of the three, and extends along the costa from inside the tip of the auxiliary vein to the tip of the first longitudinal; it also extends backwards to the base of the first posterior cell. Near the costa it contains some pale spots. The rest of the wing has numerous small brown spots, and larger ones at the apices of the first and fourth posterior cells, as well as in the anal and auxiliary cells. Posterior cross-vein in a line with the inner edge of the discal cell. Joints of the flagellum of the antennæ cyathiform. Length, ♂ 10 mm.; wing, ♂ 12 mm. The female is unknown.

Hab. Wellington (Hudson).

In both my specimens the discal cell is irregular, the cross-vein at the base of the second posterior cell being placed outside its usual position, so as to make that cell about half the length of the third posterior.

Genus RHAMPHIDIA, Meigen (1830).

"One submarginal cell; four posterior cells; a discal cell; no marginal cross-vein. The tip of the auxiliary vein is at some distance beyond the origin of the second longitudinal; the subcostal cross-vein is close to its tip. Rostrum elongated, but shorter than the thorax; last joint of the palpi elongated. Antennæ 16-jointed. Tibiæ without spurs at the tip; empodia indistinct; ungues smooth. The forceps of the male very like that of *Elephantomyia*" (Osten-Sacken).

Rhamphidia levis, sp. nov. Plate IV., figs. 12*a*, 12*b*.

General colour dark-brown; the mesonotum pale-cinerous, with three broad fuscous bands, the central one going the whole length, the outer pair terminating before the anterior border. Halteres clear, the tips fuscous. Legs fuscous, except the coxæ and bases of the femora, which are yellow. Ovipositor yellowish-brown. Wings tinted with fuscous. Antennæ very short, 12-jointed, the first joint short, the second large and cyathiform, the third stout, oval; those of the rest of the flagellum short and oval. Rostrum longer than the head and thorax together, straight; the palpi small, placed at the end of the rostrum. The auxiliary vein reaches the costa a little beyond the origin of the second longitudinal. No marginal cross-vein. Præfurca rather less than the distance from the origin of the third longitudinal to the chief cross-vein. Posterior cross-vein in a line with the inner margin of the discal cell. Length, ♀ 7 mm.; wing, ♀ 7½ mm.; rostrum, ♀ 5 mm. The male is unknown.

Hab. Wellington (Hudson).

Although the species here described has the characteristic venation of *Rhamphidia*, the antennæ and palpi differ considerably, and the rostrum is longer than the head and thorax together; but as I have only seen one specimen, which I could not dissect, I place it in *Rhamphidia* for the present.

Genus MOLOPHILUS, Curtis (1833).

"Two submarginal cells; four posterior cells; discal cell open. Wings pubescent along the veins only. Second longitudinal usually originates at a very acute angle some distance before the middle of the anterior margin; subcostal cross-vein at a considerable distance from the tip of the auxiliary vein; the præfurca ends in the first submarginal cell, which is longer than the second. The inner end of the discal cell (or, rather, as it is always open, of the second posterior cell), as well as the great cross-vein, not in one line with the small cross-vein, but much nearer to the root of the wing. Antennæ 16-jointed. Tibiæ without spurs at the tip; ungues smooth on the underside; empodia distinct" (Osten-Sacken).

Baron Osten-Sacken says that he has in his collection species from New Zaaland.

Genus TRIMICRA, Osten-Sacken (1861).

"Two submarginal cells; four posterior cells; a discal cell; the second longitudinal vein originates at a more or less acute angle before the middle of the length of the wing, and a considerable distance (more than the breadth of the wing) before the tip of the auxiliary vein; seventh longitudinal

vein straight. Wings and their veins glabrous. Antennæ 16-jointed, the three last joints of the flagellum abruptly smaller. Tibiæ without spurs at the tip; ungues small, smooth on the under-side, inserted under a projection of the last tarsal joint; empodia small but distinct. Forceps of the male with large, incrassated basal pieces, and a double, claw-shaped, horny appendage fastened to them on each side; ovipositor with flattened, curved, pointed upper valves and short lower ones" (Osten-Sacken).

Baron Osten-Sacken says that he has in his collection a species from New Zealand.

Genus GNOPHOMYIA, Osten-Sacken (1859).

"Two submarginal cells; four posterior cells; a discal cell; the second longitudinal vein originates somewhat before the middle of the anterior margin, a considerable distance anterior to the tip of the auxiliary vein; præfurca very slightly arcuated at the basis, nearly straight; subcostal cross-vein at a small or moderate distance (hardly exceeding the length of the great cross-vein) from the tip of the auxiliary vein; seventh longitudinal vein nearly straight. Wings glabrous. Antennæ 16-jointed. Tibiæ without spurs at the tip; tarsi with distinct empodia. The forceps of the male consists of two comparatively short basal pieces and a pair of claw-shaped, horny appendages; a second pair of horny appendages, below the first, is shorter and stouter" (Osten-Sacken).

Gnophomyia rufa. Plate IV., fig. 13.

Tipula rufa, Hudson, Trans. N.Z. Inst., vol. xxvii, p. 294 (1895).

Length, ♂ 27 mm.; wing, ♂ 21 mm. The female is unknown.

Hab. Wellington and Nelson (Hudson).

This fine species answers well to Osten-Sacken's definition of *Gnophomyia*. The antennæ are 16-jointed, the joints of the flagellum oval. The rostrum is shorter than the head. The eyes are contiguous. The empodia are large. There are no tibial spurs. The origin of the second longitudinal is very oblique. The first submarginal cell is nearly as long as the second. The seventh longitudinal vein is straight for some distance, and then turns sharply backwards, joining the margin at a high angle; the posterior cross-vein enters the discal cell at about one-third of its length from the inner margin. The wings are glabrous, and orange in colour. There is a dark oblique streak from the tip of the first longitudinal, through the fork of the second longitudinal, into the

anterior basal cell. Another dark streak borders the seventh longitudinal vein.

Genus Limnophila, Macquart (1834).

"Two submarginal cells; usually five, seldom four, posterior cells; discal cell closed; subcostal cross-vein posterior to the origin of the second longitudinal vein, usually closely approximated to the tip of the auxiliary vein. Wings glabrous. Eyes glabrous. Antennæ 16-jointed. Tibiæ with spurs at the tip; empodia distinct; ungues smooth" (Osten-Sacken).

Of the species here described, *L. delicatula*, *L. marshalli*, *L. umbrosa*, and *L. geographica* have short tibial spurs, not much longer than the breadth of the tibia, which are not easily seen among the hairs, and they may, perhaps, form a distinct genus. *L. crassipes* also departs from the true *Limnophila* in having no empodia, so that only two of our species are really typical. In all, however, the eyes are separated, showing that they are rightly placed near *Limnophila*. All the known New Zealand species have five posterior cells.

Key to the Species.

Posterior cross-vein arising near the inner end of the discal cell.
- Wings ochraceous .. .. *L. sinistra.*
- Wings colourless .. .. *L. delicatula.*

Posterior cross-vein arising in the middle of the discal cell.
- Subcostal cross-vein inside the tip of the auxiliary.
  - Spots at costal cross-vein and tip of auxiliary united .. .. *L. umbrosa.*
  - Spots at costal cross-vein and tip of auxiliary separate .. .. *L. marshalli.*
- Subcostal cross-vein close to the tip of the auxiliary.
  - Wings with ocellated spots .. .. .. *L. argus.*
  - Wings with simple spots .. .. .. *L. crassipes.*

A. Tibial spurs long.

a. Empodia present.

Limnophila sinistra. Plate IV., fig. 14.

Tipula obscuripennis, Hudson, Trans. N.Z. Inst., vol. xxvii., p. 294 (1895); not *Limnophila obscuripennis*, Skuse (1890).

Yellowish-brown; head and rostrum, sides of the thorax, and a stripe on each side of the abdomen fuscous. Joints of the antennæ dark-brown at the base. Fore and middle femora with three fuscous bands; hind femora with the proximal half, the knee, and a narrow band inside it fuscous. Wings pale-yellowish, dotted with brown. A short brown band at the origin of the second longitudinal vein; another, much longer, from the tip of the auxiliary along the chief and posterior cross-veins. Others at the apices of the discal and

fifth posterior cells. Smaller brown spots at the base of the second posterior cell, and at the tips of the hinder branch of the fourth and the intercalary veins. The second longitudinal, at its origin, bends almost at a right angle. The posterior cross-vein is sinuated, and joins the inner margin of the discal cell. The subcostal cross-vein is at a short distance behind the tip of the auxiliary but outside the chief cross-vein. Length, ♂ 14 mm., ♀ 12 mm.; wing, ♂ 15 mm., ♀ 14 mm.

Hab. Wellington (Hudson).

Limnophila argus, sp. nov.

Pale-brown, marked with fuscous. Head, mesonotum, margins of the metanotum, and a band on each side of the thorax from head, under the wing, to the metanotum, fuscous. Scutellum pale. First abdominal segment pale; second and third dark, with a pale central mark; the anterior half of the others dark, while the posterior half is pale, with a wedge-shaped dark dorsal mark, which has two yellow spots near its base. Femora pale-brown, with two dark rings near the tip; tibiæ and tarsi dark-brown. Wings hyaline, with ocellated brown spots on the origin and on the fork of the second longitudinal, at the marginal cross-vein, at the fork of the anterior branch of the fourth longitudinal, at the tip of the seventh longitudinal, and another inside it. Also simple rings at the tips of most of the longitudinal veins and on the posterior cross-vein; brown bands on the chief cross-vein, and at the outer margin of the discal cell. The subcostal cross-vein is close to the tip of the auxiliary. The first submarginal cell is three-fourths of the length of the second. The posterior cross-vein enters the discal cell near the middle. Length, ♂ 14 mm., ♀ 19 mm.; wing, ♂, ♀ 15 mm.

Hab. Wellington (Hudson).

β. Empodia absent.

Limnophila crassipes, sp. nov. Plate IV., fig. 15.

Pale yellowish-brown; mesonotum with indistinct brown bands. The tips of the femora and a ring a little inside them dark-brown; tarsi dark-brown. Wings dirty-yellow, the veins brown; pale-brown spots at the origin of the second longitudinal, at the tip of the auxiliary, at the origin of the third longitudinal, in the middle of the first submarginal cell, at the base of the posterior basal cell, and on the posterior cross-vein. The subcostal cross-vein is near the tip of the auxiliary. The first submarginal cell is about three-quarters of the length of the second. The posterior cross-vein enters the discal cell near the middle. The tibial spurs are long, and the ungues are large, but there are no empodia. Length, ♀ 12 mm.; wing, ♀ 19 mm. The male is unknown.

Hab. Wellington (Hudson).

This is a robust species, with thickish legs and no empodia. It has five posterior cells. The rostrum is thick, nearly vertical, and about as long as the head.

B. Tibial spurs short.

Limnophila delicatula, sp. nov.

Uniform brown, the abdominal segments with paler posterior margins. Halteres fuscous. Wings clear, without spots or stigma; the veins fuscous. Five posterior cells. Subcostal cross-vein close to the tip of the auxiliary. The præfurca forms more than a half of the second longitudinal. The posterior cross-vein joins the discal cell at a distance from its inner margin which is less than one-fourth of its length. Length, ♀ 12½ mm.; wing, ♀ 13 mm. The male is unknown.

Hab. Wellington (Hudson).

The tibial spurs and empodia are short but distinct. The legs are particularly long and slender.

Limnophila marshalli, sp. nov. Plate IV., fig. 16.

Dark-brown; coxæ and femora pale yellowish-brown, the latter with fuscous tips and a fuscous band near the tip; tibiæ and tarsi fuscous. First and second joints of the antennæ pale yellowish-brown, the flagellum fuscous. Halteres yellowish, with fuscous tips. Wings pale-yellowish, with brown spots at the origin of the second longitudinal, at the subcostal cross-vein, at the tips of the auxiliary and first longitudinal, on the chief cross-vein, at the outer margin of the discal cell, at the base of the second posterior cell, on the posterior cross-vein; two in the posterior basal cell, one in the axillary cell, and others at the tips of all the longitudinal veins. Subcostal cross-vein far from the tip of the auxiliary and in a line with the chief cross-vein. First submarginal cell not much more than half the length of the second. Posterior cross-vein entering the discal cell near the middle. Seventh longitudinal vein sinuated. Length, ♀ 10 mm.; wing, ♀ 11 mm. The male is unknown.

Hab. Wellington (Hudson).

I have named this species in honour of Mr. P. Marshall, the author of three excellent papers on New Zealand *Diptera* in the "Transactions of the New Zealand Institute," vol. xxviii. The tibial spurs are small, and lie close under the metatarsi; the empodia are distinct. The eyes are separated. The antennæ are 16-jointed; those of the flagellum are cylindrical, except the two last, which are oval.

Limnophila umbrosa, sp. nov.

Pale-brown, marked with darker brown. Sides of the pronotum, a central band on the rest of the thorax, and a band on each side of the abdomen, dark-brown. Femora pale-brown, with two dark bands on the distal half; tibiæ and tarsi dark-brown. Wings subhyaline, with pale-brown markings. A round spot near the basal cross-vein; a large semicircular fascia from the origin of the second longitudinal, through the anterior basal cell and the chief cross-vein, to the subcostal cross-vein, and spreading out to the tip of the auxiliary vein. Spots at the apices of the second subcostal and submarginal cells, at the base of the second posterior and apex of the discal cells, on the posterior cross-vein, and at the tips of all the longitudinal veins. Subcostal cross-vein far from the tip of the auxiliary, and in a line with the chief cross-vein. The posterior cross-vein enters the discal cell about the middle. Length, ♀ 9 mm.; wing, ♀ 12 mm. The male is unknown.

Hab. Wellington (Hudson).

In this species, like the last, the tibial spurs are short, and lie under the metatarsi; the empodia are distinct. The first nine joints of the flagellum are cylindrical, the last five are oval.

Limnophila geographica, sp. nov.

Thorax brown, the pronotum and a band on each side of the mesonotum yellow; scutellum with two round fuscous spots. Palpi and antennæ fuscous, except the base of the flagellum, which is yellow; rostrum yellow. Abdomen pale-brown, with a dark-brown stripe on each side, the two last segments dark-brown. Coxæ very pale-yellow; femora brownish-yellow, with the proximal ends and two broad bands on the distal half fuscous; tibiæ yellowish-brown; tarsi fuscous. Wings colourless, except the costal cell, which is yellowish, and several fuscous spots and fasciæ. Two large spots at the basal cross-vein and at the origin of the second longitudinal, between which there are two small spots in the costal cell. A large dark mark extends on the costa from the tip of the auxiliary to that of the anterior branch of the second longitudinal, going inwards to the base of the discal and apex of the anterior basal cells. A dark curved fascia from the centre of the first posterior cell, through the apex of the discal, and reaching the margin of the wing between the tips of the fifth and seventh longitudinal veins. Small spots at the tips of the longitudinal veins, and another near the anal angle of the wing. The subcostal cross-vein is close to the tip of the auxiliary. The first submarginal cell is more than

three-fourths the length of the second. There is a stump at the angle of the præfurca. The posterior cross-vein enters the discal cell at about three-quarters of its length from the hind margin. Length, ♂ 12 mm.; wing, ♂ 13 mm. The female is unknown.

Hab. Wellington (Hudson).

In this species, like the two last, the tibial spines are short, and pass below the metatarsus. The empodia are distinct. The antennæ are 16-jointed; the joints of the flagellum cylindrical.

Genus Tinemyia, gen. nov.

Two submarginal cells; five posterior cells; a discal cell; subcostal cross-vein beyond the origin of the second longitudinal. Wings and eyes glabrous. Antennæ 16-jointed. Rostrum longer than the head and thorax together, the palpi near the tip. Tibiæ with short spurs. Empodia indistinct or none. Ungues smooth.

Notwithstanding its short tibial spurs, which are less than the breadth of the tibia, the venation of the wings shows that this genus belongs to the *Limnophilinæ*. I have only seen a single female specimen, and so can give no account of the forceps of the male.

Tinemyia margaritifera, sp. nov. Plate IV., figs. 17*a*, 17*b*.

Brown, the tips of the first six joints of the flagellum of the antennæ and the whole of the last joint pale. The knee-joints are also pale. Antennæ long; the first joint short and stout, the second cyathiform, those of the flagellum cylindrical, except the last, which is oval, and broader than the others. Rostrum twice as long as the head and thorax taken together; the palpi short, 3-jointed. Halteres very long, brown. The ovipositor pale at the tip. Wings brown, with numerous small pale-yellow spots and lines. About nine spots, either circular or semicircular, in the costal cell; a larger one crossing the second subcostal and first submarginal cells; another in the second marginal. Others in the middle portion of the wing, chiefly as short straight or curved cross-streaks. Four round spots in the anal cell. Veins fuscous. Subcostal cross-vein close to the tip of the auxiliary. First submarginal cell about three-fourths the length of the second. Posterior cross-vein entering the discal cell at about one-third of its length from the inner margin. Length, ♀ 15 mm.; wing, ♀ 14 mm.; antenna, ♀ 4 mm.; rostrum, ♀ 6 mm. The male is unknown.

Hab. Wellington (Hudson).

Genus GYNOPLISTIA, Westwood (1835).

Two submarginal cells; five (rarely four) posterior cells; discal cell generally closed; auxiliary vein reaching the costa nearly opposite the base of the second submarginal cell. First submarginal cell with a short petiole. Seventh longitudinal vein distinctly sinuated. Wings and eyes glabrous. Antennæ 15- to 22-jointed; most of the flagellar joints unipectinate in both sexes, or serrate in the female. Tibiæ spurred. Empodia distinct. Ungues smooth. Male forceps like that of *Limnophila*, usually with one horny claw-shaped appendage. Ovipositor long and pointed.

Baron Osten-Sacken says that he has in his collection a species of *Gynoplistia* from New Zealand, in which the wings in both sexes are rudimentary.

KEY TO THE SPECIES.

Abdomen not metallic.
- Tips of the femora fuscous .. .. .. *G. subfasciata.*
- Tips of the femora subfuscous .. .. .. *G. wakefieldi.*

Abdomen metallic.
- A dark spot at the origin of the præfurca.
  - Tips of the wings fuscous .. .. .. *G. cuprea.*
  - Tips of the wings clear .. .. .. *G. formosa.*
- No dark spot at the origin of the præfurca .. *G. fulgens.*

Gynoplistia subfasciata.

Gynoplistia subfasciata, Walker, List of Diptera in Brit. Mus., p. 74 (1848). *Cloniophora subfasciata*, Schiner, Reise der "Novara," Diptera, p. 40; Cat. Dipt. of N.Z., p. 16: Hudson, Man. of N.Z. Entomology, p. 50, pl. v., figs. 3, 3*a*.

Brown, the thorax with four hoary stripes. Femora with a pale tawny band near the tip. Wings slightly tawny, with a brown spot at the origin of the second longitudinal vein, and a brown fascia from between the tips of the auxiliary and first longitudinal, through the chief cross-vein, to the inner margin of the discal cell. Outer margin of the discal cell and the posterior cross-vein also brownish. Another brown spot about the middle of the sixth longitudinal. The antennæ are 15-jointed, the third to the twelfth being unipectinate in the male. They are branched in both sexes. Length, ♂ 16 mm., ♀ 20 mm.; wing, ♂ 13 mm., ♀ 14 mm.

Hab. Throughout New Zealand.

Schiner's genus *Cloniophora*, made for this species, is not allowed by Osten-Sacken.

Gynoplistia wakefieldi.

Cloniophora wakefieldi, Westwood, Trans. Ent. Soc. of London, 1881, p. 372, pl. 18, fig. 5.

Cinerous, the apex of the abdomen subcastaneous. An-

tennæ black, 16-jointed; ♂ with 3 to 13 branched, ♀ with 4 to 11 serrated. Rostrum short. Thorax with a small obscure spot on each side, and four blackish stripes on the dorsum. Wings limpid, with fuscous spots; a short oblique fascia from the tip of the first longitudinal to the base of the discal cell; a row of four to six spots in the posterior basal cell. Legs reddish; femora with a pale ring before the apex. Length, ♂ 10 mm., ♀ 16 mm. Expanse of the wings, ♂ 20 mm., ♀ 22 mm. (Abbreviated from Westwood.)

In two specimens in Mr. Hudson's collection the brown bands are quite as well marked as in *G. subfasciata*, but the legs are paler, and the femora are only subfuscous at the tip. so that the pale band is not so distinct. In the female the posterior basal cell has no spots, although they are present in the male. The antennæ of the male are 18-jointed, with 3 to 15 branched, and the branches are much longer than in *subfasciata*, and much longer than in Westwood's figure. Length, ♂ 14 mm., ♀ 17 mm., wing, ♂ 12 mm., ♀ 13 mm.

Hab. New Zealand (D. Wakefield); Wellington (Hudson).

I doubt much whether this species can be kept distinct from *G. subfasciata;* evidently the antennæ and the markings of the wings are variable, and we have only size and colour of the legs to trust to.

Gynoplistia cuprea.

Gynoplistia cuprea, Hudson, MSS. Plate IV., fig. 18.

Metallic copper-yellow, with purple reflections. Antennæ dark-brown, in the male 20-jointed, the third to the sixteenth branched. A large patch on each side of the thorax with pale-yellowish hairs. Halteres yellow. Femora pale yellowish-brown. Wings ochraceous, darker in the female, with brown spots at the origins of the second and third longitudinal veins. Tips of the wings brown. Length, ♂ 11–11½ mm., ♀ 16 mm.; wing, ♂ 11–12 mm., ♀ 15 mm.

Hab. Wellington (Hudson), Canterbury (F.W.H.).

Gynoplistia formosa, sp. nov.

Abdomen metallic steel-blue, with purple reflections. Head and antennæ dark-brown. Thorax dark-bronze. Legs dark-brown, the femora (except the tips) and a distal ring on the hind tibiæ yellow. Halteres yellow. Wings faintly tinged with yellow; a large dark spot at the origin of the second longitudinal vein, and a still larger one from the costa through the bases of the second submarginal and first posterior cells to the discal, which is clear, except the inner and outer margins. A lighter spot in the upper margin of the axillary cell, about two-thirds from the base, and touching the sixth longitudinal vein. The antennæ in the male are 22-jointed, of

which 3 to 17 are branched; the last joint is small. Length, ♂ 12 mm.; wing, ♂ 11 mm. The female is unknown.

Hab. Wellington (Hudson).

Gynoplistia fulgens, sp. nov. Plate IV., fig. 19.

Abdomen metallic steel-blue, with purple reflections. Head and antennæ dark-brown. Thorax black, shining. Halteres yellow. Legs blackish-brown, the proximal portions of the femora yellowish-brown. Wings clear, except at their bases, where they are slightly tinged with yellow; a rather pale-brown spot at the apex of the marginal cell, extending across the base of the second submarginal. Only a minute spot at the origin of the second longitudinal vein. Discal cell open. Antennæ in the male 20-jointed, of which 3 to 15 are branched. Length, ♂ 13 mm.; wing, ♂ 12 mm. The female is unknown.

Hab. Wellington (Hudson).

Genus CEROZODIA, Westwood (1835).

"Antennæ 32- to 39-jointed, all but the first two and the last with a long branch. Rostrum not longer than the head; palpi rather long. Thorax small; abdomen narrow, of equal breadth, very slightly broader at the forceps, which is formed as in *Gynoplistia*. Legs rather stout; tibiæ with spurs; empodia present. Venation of wings as in *Gynoplistia*, except that the subcostal cross-vein is almost obsolete, so that the auxiliary vein appears to end in the first longitudinal; first submarginal cell rather long, its proximal end but little distad of the proximal end of the second submarginal; the second posterior cell with a long petiole; the great cross-vein near the middle of the discal cell" (Osten-Sacken).

Cerozodia plumosa. Plate IV., fig. 20.

Cerozodia plumosa, Osten-Sacken, Berliner Entomol. Zeitschrift, 1887, p. 213.

"*Male.*—General colour reddish-brown, without any distinct thoracic stripes; a narrow black stripe on each side of the abdomen, along the suture. Antennæ yellowish-red, the branches brown. On the wings the subcostal cell and the stigma are infuscated; a large pale-brown cloud between the stigma and the discal cell; a smaller one at the origin of the præfurca; yellowish-brown clouds along the veins. Antennæ with 39 joints. Length, 25–26 mm." (Osten-Sacken).

Hab. New Zealand (Osten-Sacken); Lake Wakatipu (Hudson).

The female is unknown. In Mr. Hudson's specimen the wing measures 23 mm.

Sub-family PTYCHOPTERINÆ.

V-shaped suture of the mesonotum indistinct. Structure of the ovipositor various.

Genus Tanyderus, Philippi (1865).

Head placed at the end of a long cylindrical neck. The rostrum longer than the head; palpi 4-jointed, the last joint shorter than the penultimate. Eyes pubescent in the female, glabrous in the male; contiguous in both sexes, no ocelli. Antennæ 18-jointed; the first joint short and cyathiform, the second globular, those of the flagellum cylindrical, the last less than half the length of the penultimate. Thorax with tuberosities over the wings, but the sutures are not connected across the dorsum. Wings with hairs on the veins; one marginal cell, five submarginal cells, and five posterior cells. Discal cell closed. Basal cells less than half the length of the wing. Subcostal cross-vein near the tip of the auxiliary. A posterior intercalary vein. Seventh longitudinal vein absent, represented by a short fold. Tibiæ with long spurs at their tips. Empodia absent. Ungues smooth. The forceps in the male is large, simple, 3-jointed; the last joint blunt, without any teeth or horny claw. No ovipositor, but a pair of anal styles.

In this genus there is a discal cell; the anterior branch of the second longitudinal vein is forked, and the lower branch of the fork is connected by a cross-vein with the posterior branch. This posterior branch of the second is also connected by a cross-vein with the third longitudinal, thus making five submarginal cells. The origin of the third longitudinal is a little beyond the first fork of the second. The anterior branch of the fourth longitudinal is not branched, but the fourth posterior cell is divided into two by a posterior intercalary vein, thus making five posterior cells. The length of the discal cell is about four times its breadth. The posterior cross-vein is very oblique. The sixth longitudinal vein is present. The abdomen is narrow and cylindrical, with, apparently, seven segments in the male and eight in the female.

Tanyderus annuliferus, sp. nov. Plate IV., figs. 21*a*–21*e*.

Brownish-yellow, the joints of the legs and tarsi dark-brown. Head dark-brown. Mesonotum with three dark-brown bands, the pleuræ dark-brown. Tips of the halteres dark-brown. Wings nearly hyaline, with brown markings; all the longitudinal veins with hairs in both sexes. The markings on the wings consist chiefly of three brown fasciæ containing white spots, one at the base of the wing, another

through the apices of the basal cells, and a third, which is Y-shaped, through the apex of the discal cell. There are also spots on the hind margin of the wing between these fasciæ, and brown rings at the tips of most of the longitudinal veins. Length, ♂ 13 mm., ♀ 18 mm.; wing, ♂ 31 mm., ♀ 34 mm.; antennæ, ♂, ♀ 3 mm.; hind femur, ♂, ♀ 9 mm.; fore femur, ♂ 7 mm., ♀ 8 mm.

Hab. Wellington (Hudson).

The hind tibia and hind tarsus are each of the same length as the hind femur; but the fore tarsus is longer than the fore femur, and longer even than the hind tarsus. The posterior cross-vein arises at the inner angle of the discal cell, so that the base of the fourth posterior cell is pointed.

Tanyderus forcipatus. Plate IV., fig. 22.

Tanyderus forcipatus, Osten-Sacken, Verh. z.-b. Wien, xxix., p. 520 (1879).

Reddish-brown. Head and neck dark-brown. Thorax cinerous, the centre of the mesonotum dark-brown, divided by a pale longitudinal line. Halteres dark-brown. Abdomen brown, with a row of cinerous spots on each side; the anal styles orange. Coxæ, femora, and hind tibiæ reddish-brown; all the joints fuscous. Wings white, with brown markings, the costal cell yellowish, the veins dark-brown. The auxiliary, the first longitudinal, and the anterior branch of the second longitudinal alone have hairs. The markings on the wings are two round spots on the costa, one of which, at the origin of the second longitudinal, is encircled by a broad band which passes through the apices of the basal cells and through the anal cell to the base of the wing; the other is at the apex of the auxiliary vein, and outside it there is a broad oblique fascia through the base of the first submarginal and apex of the discal cells to the tip of the sixth longitudinal, but is interrupted along the posterior intercalary vein. Tips of the wings and a spot at the end of the posterior branch of the fourth longitudinal and one on the posterior margin of the axillary cell brown. Length, ♀ 15 mm.; wing, ♀ 15 mm.; hind femur, ♀ 8 mm.; fore femur, 8 mm.

Hab. Wellington (Hudson); Otago (F. W. H.).

The legs are more robust than in the last species. Neither of the hind tarsi are perfect in my specimen. The posterior intercalary vein arises from the posterior cross-vein a short distance below its junction with the fourth longitudinal, so that the fourth posterior cell has a flat base.

APPENDIX.

The following new species, from the Auckland Islands, have been described by Professor Josef Mik, of Vienna, in the Verhandlungen der zoologisch-botanischen Gesellschaft in Wien, vol. xxxi., pp. 195–206 (1881) :—

Dicranomyia insularis.

♂. Cinereo-fusca, abdomine fasciis apicalibus transversis obscurioribus, segmentorum incisuris ipsis pallidioribus; alis infumatis, stigmate fusco, venis longitudinalibus conspicue pilosis; apice venæ auxiliaris basi venæ longitudinalis secundæ opposito; venula transversa inter venam auxiliarem et longitudinalem primam inconspicua, ab apice venæ auxiliaris satis remota. Forcipis maris articulis terminalibus permagnis, in latere interiore in rostrum corneum bisetosum productis. Long. corp. 6 mm., long. alar. 8 mm.

Dicranomyia kronei.

♂. Tota fusca, femoribus ad basin et forcipe dilutioribus; alis infuscatis, immaculatis, stigmate pallido, costa intra venam auxiliarem et tertiam longitudinalem valde incrassata; vena auxiliari ultra basim venæ longitudinalis secundæ excurrente; venula transversa inter auxiliarem et longitudinalem venam primam obsoleta, ab apice venæ auxiliaris parum remota et origini venæ longitudinalis secundæ opposita; venula transversa cellulam discoidalem a cellula basali anteriori separante subrecta. Long. corp. 6 mm., long. alar., 8 mm.

Trichocera antipodum.

♂, ♀. Cinereo-fuscana, genitalibus pedibusque dilutioribus; alis pallide infuscatis, immaculatis, vena transversa ordinaria cellulæ discoidalis subtrigonæ basim attingente; ramis furcæ, cellulam discoidalem egredientis, multo longioribus quam illius furcæ pedicellus; segmento venæ longitudinalis quintæ ultimo triplo longiore quam vena transversa posterior. Feminæ ovipositore naviculiforme. Long. corp. 4 mm., long. alar. 5 mm.

Limnophila bryobia.

♂. Nigra, halteribus testaceis, clava ad apicem nigra; alis latis, infumatis, stigmate dilute nigro-fusco, cellulis posterioribus quatuor. Long. corp. 9 mm., long. alar. 10 mm., latitudo alarum, 3·3 mm. (ab venæ auxiliaris apice usque ad apicem venæ longitudinalis sextæ).

EXPLANATION OF PLATES III. AND IV.

PLATE III.

Fig. 1. *Dolichopeza atropos*, wing.
Fig. 2. *Pachyrhina hudsoni*, *a*, wing; *b*, antenna; *c*, male forceps from above; *d*, male forceps from below.
Fig. 3. *Tipula fulva*, wing.
Fig. 4. *Tipula viridis*, *a*, wing; *b*, antenna.
Fig. 5. *Tipula obscuripennis*, wing.
Fig. 6. *Tipula dux*, wing.
Fig. 7. *Macromastix binotata*, wing.
Fig. 8. *Dicranomyia monilicornis*, wing.
Fig. 9. *Geranomyia annulipes*, *a*, wing; *b*, rostrum.
Fig. 10. *Trochobola ampla*, wing.
Fig. 11. *Trochobola picta*, wing.

PLATE IV.

Fig. 12. *Rhamphidia levis*, *a*, wing; *b*, antenna.
Fig. 13. *Gnophomyia rufa*, wing.
Fig. 14. *Limnophila sinistra*, wing.
Fig. 15. *Limnophila crassipes*, wing.
Fig. 16. *Limnophila marshalli*, wing.
Fig. 17. *Tinemyia margaritifera*, *a*, wing; *b*, tip of rostrum.
Fig. 18. *Gynoplistia cuprea*, wing.
Fig. 19. *Gynoplistia fulgens*, wing.
Fig. 20. *Cerozodia plumosa*, wing.
Fig. 21. *Tanyderus annuliferus*, *a*, head and thorax; *b*, head, side view; *c*, antenna; *d*, anal styles of female; *e*, forceps of male.
Fig. 22. *Tanyderus forcipatus*, wing.

ART. X.—*On Hereditary Knowledge.*

By RICHARD HENRY.

Communicated by Sir James Hector.

[*Read before the Wellington Philosophical Society, 11th July, 1899.*]

I REMEMBER reading about the young swallows taking their flight from England when they had been only a few days on the wing; and, when we know nothing to the contrary, we are likely to assume that their parents led them away and taught them the geography of the country they were going to. But I have seen young "shining cuckoos" at Te Anau as late as April, apparently alone and quite happy, though they had a thousand-mile flight before them immediately, if they wished to survive; and no one to show them the way, for it is probable that a young cuckoo never sees its mother except by accident.

As far as our knowledge goes, the cuckoos leave their eggs and young entirely to foster-parents, who are not likely to teach

any cuckoo lore. Therefore the knowledge of geography and their own peculiar impressions must have been laid in the egg, or, in other words, must have been hereditary; and why not the same with the swallows?

If the parent swallow has to lead her young and point out routes and localities, it is a very poor plan compared with that of the cuckoos; because, if anything happened to the parents, or if they were getting old or weakly, their young would perish with them for want of the knowledge that could as well have been laid in the egg.

Every one knows that a trout will teach nothing to its young ones, but will eat them at the first opportunity; yet they know all about visible fishing-lines, and the way to ascend rivers and rapids at the appointed time, which must be hereditary, when they had no experience and no teachers.

The young snipes, flying away to some far-off country, may have all the geographical knowledge that their parents had gathered for ages as to where and when to find the marshes and springs that shelter their food in a land that they had never seen, and probably never heard of. Therefore the long flights of migratory birds may be directed by knowledge derived from far-distant parents that first made their journeys when land was almost continuous.

What a wonderful thing is mind, of which we seem only to have a part, deficient in valuable faculties that other animals possess—deficient in memory and thought, and in the power of transmitting or even retaining the hard-earned acquirements that our youngsters need so much.

However, I saw recently in Dunedin what I take to be a case of hereditary aptitude in a little boy, who was better read and more intelligent at nine years of age than many boys at sixteen. And when we remember our progress in the last generation there appear great possibilities in the next few thousand years, which will skip away like hours when our time is up. Then, if any of us are allowed to look back at this old world, we may see hereditary knowledge becoming a part of men's minds, and ignorance and imposture things of the past. The power of heredity to improve we readily admit among animals, but ignore in ourselves, not because its laws are so obscure, but because our whims are easier to follow; and, though we experiment in all other branches of science, this, the most important of all, we have hardly the courage to touch.

ART. XI.—*On the Probable Origin of* Notornis mantelli, *and its Extinction in New Zealand.*

By RICHARD HENRY.

Communicated by Sir James Hector.

[*Read before the Wellington Philosophical Society, 11th July, 1899.*]

MANY readers will remember that the swamp-hen was mentioned in Cook's voyages at various places in the Pacific, and every one knows that our bird is common in Australia under a variety of names, of which swamp-hen is about the best, because it is simple and accurately descriptive. Thus we may assume that it is migratory, and in the case of the *Notornis* (which is also a rail) may have a history parallel to that of the wood-hen. Coming here long ago in search of the New Zealand swamps—of which it may have had a hereditary geographical knowledge—and becoming tired or storm-bound, it dropped down in the West Coast bush, where seeds were abundant before the advent of rats, and where there were no enemies on the ground. The sparrow-hawk was probably their worst enemy in New Zealand, because the swamp-hen cannot turn and twist on the wing, but flies straight, and offers a splendid mark for the swooping hawk. I have seen them knock down several swamp-hens, and, ferret-like, sometimes only drink their blood. If those hawks were plentiful it must have been a great inducement for the old swamp-hens to stay in the scrub, until at last they were too lazy to fly, especially those that had escaped a knock or two from the hawks. Then, with mates of like experience, there is no mystery about the founding of this notable family—a branch of which exists in the white swamp-hen of Norfolk Island.

A curious item was told me this morning by Mr. Nixon, of H.M. Customs. About twenty years ago the "Gleaner" (Captain Agnew) came into Greymouth with a strange bird aboard, which turned out to be a New Zealand or Australian swamp-hen, that came to the vessel for a rest four hundred miles from the New Zealand coast, and was captured by the crew. There is no doubt about this fact, notwithstanding our habit of thinking that swamp-hens are poor fliers; and there need be as little mystery about the disappearance of the *Notornis* when we come to know the facts. The rats at my homestead will never allow a single grain of oats to ripen, but eat it all in the soft stage, and they take about 70 per cent. of the grass-seed. The native thrush and the kakapo can shell oats nearly as well as a sparrow, though I know of no such grain in the bush. This gives us a hint of what kind

of birds would naturally be exterminated. The rats will also eat turnips, cabbages, gooseberries, and peas. It is said that Captain Cook got spinach in Dusky Sound, but I have seen nothing of it in my four years' perambulations, though I know the plant well. Perhaps the rats ate it. They go down on to the mud-flats and carry up cockles, some of which they bite and eat fresh, but most they leave to die and open of their own accord. This "side dish" allows them to hunt up the last seed in the bush, and in this their scent gives them a great advantage over the birds. This alone would account for the abundance of rats and scarcity of the *Notornis*.

But nearly all grass- and vegetable-eaters depend on seeds for rearing their young, and it must be a long time since the *Notornis* had a fair opportunity of rearing her chickens, especially when strength of beak denotes that she was essentially a seed-eater. Thus we may infer that they would breed like rabbits on the seeds that we could give them, if only we could catch a live pair. It is, alas, a forlorn hope on the coast, but might be possible yet at Te Anau.

Art. XII.—*On Tuberculosis in Pheasants in Wanganui.*

By S. H. Drew, F.L.S.

[*Read before the Wellington Philosophical Society, 8th August, 1899.*]

Some little time ago several of the acclimatisation societies on this coast joined with the Wellington Society to procure live game from England. Our local society elected to import the long-tailed Reeves pheasant (*Phasianus reevesii*). Before the birds arrived I had a large place enclosed at the rear of the Museum, and everything was ready for them when they arrived by the "Ruapehu" some eighteen months ago. The boxes of birds came from the "Ruapehu" by local steamer, and on arrival I at once took them to the Museum and let them out in the place prepared for them. I wish to say here that the boxes the birds were brought out from England in were cruelly small, each bird being in a separate compartment of the following size: 11 in. wide, 18½ in. high, and 23½ in. deep: so small, indeed, were they that the tail-feathers of the birds had to be cut quite close to the body to get them into the box, and I doubt if the birds could have turned round when inside. One bird was dead on arrival, and the wings of two others were broken and hanging down. I washed these and set them as well as I was able. In the

course of time moulting came on; the beautiful new plumage took the place of the old dirty feathers, and the cock-birds looked magnificent in their gorgeous colours and long 4 ft. tails.

All the birds being now fully feathered, and seeming in splendid health, the society decided to liberate them. This was done some distance up the Wanganui River. The pair with the mended wings were not turned out, as it was considered that there was a danger of their being destroyed by dogs, and it was also hoped that the pair would rear a brood of young ones. The hen laid eleven eggs, but would not sit, so the eggs were placed under a domestic hen, who hatched them out, but, unfortunately, trod them to death soon afterwards. During the time of their captivity the birds improved in appearance; they ate well, and looked strong and healthy, and showed no outward indication of disease. On Sunday, the 2nd July, the cock-bird began to mope, and, although still eating food, died on the following Thursday. I opened the bird and found the liver about six times larger than normal, and closely studded with nodules or cysts containing a yellow cheesy matter, and varying in size up to ½ in. in diameter. Dr. Connolly of this town (one of the presidents of our society) examined the bird with me, and pronounced the trouble to be tuberculosis. Nor was the liver only in this state; all the organs were more or less diseased. The lungs appeared to be most healthy; at the same time there was a very large nodule at the bottom of the right lung. The body was not emaciated, but rather well nourished. Being such an interesting specimen, I wrapped it in cloth, wetted with a solution of formol, and posted it to the Chief Veterinarian, Mr. Gilruth, Wellington, who writes, "The disease affecting this animal is tuberculosis in a most advanced stage, almost every organ being implicated. The nodules in the liver and lungs, when examined microscopically, are found to be filled with masses of the characteristic bacillus."

Now, where did the bird contract the disease? Was it before it reached New Zealand or afterwards? Many are of the opinion that had the bird developed tuberculosis before coming here it would have died, and not have lived in apparent health for eighteen months after its arrival here. In spite of this opinion I think it hardly possible for the birds, while under my care, to have come in contact with the bacillus indicated for many reasons. To start with, the aviary was built on the sandhill at the rear of the Museum; it was not old ground. About four years ago some feet of the sand was stripped off in levelling the site, and the land has been close fenced ever since. No rubbish or anything was thrown there; no animals were kept in the enclosure; grass was growing strongly; nothing could drain into the

land; and it was never wet, as drainage went away at once. The birds were fed with the best corn and other seeds, sopped bread with water, cabbage, and lettuce. The water used for the birds was always rain-water, and no other birds were with them. No meat, liver, or milk was given them as food. They were in a private part of the Museum grounds, and the public could not get to them. The only creatures we ever saw in the avairy were sparrows and rats. Could the rats communicate the disease? I should add that after the birds had been here one month a hen died, and later on I lost a cock-bird, but unfortunately, I am sorry to say, I made no examination of either. I have since heard that other societies who imported the Reeves pheasant lost all by death before turning out.

Art. XIII.—*Crossing with the Muscovy Duck.*

By Coleman Phillips.

[*Read before the Wellington Philosophical Society, 11th July, 1899.*]

The specimen before members was bred by crossing some pure-bred Muscovy ducks, imported from Sydney about the year 1892, with, I believe, a pure-bred slaty-blue Andalusian drake (if that is the proper name of the breed, being of the same colour as the Andalusian fowls), which are often brought into Wellington from the neighbouring coast ports and sold by the auctioneers about February and March in each year. I only managed to rear one of this cross myself, but a sitting of the eggs I gave to Mr. W. J. Martin, of Huangaroa (in the Wairarapa), about October, 1898. He was lucky enough to hatch out three drakes, one of which is now before the meeting. On the 29th March, 1899, being about four months old, this duck weighed 4½ lb. without the skin, &c. It appears so excellent a cross that Sir James Hector has very kindly had the bird stuffed. Great credit is due to Mr. Martin for the admirable manner in which he has reared this drake. The result shows what good feeding and a good cross will do—he reared it chiefly upon pollard and soaked wheat. As we are anxious to breed good poultry for the English market this specimen may prove useful as a guide. The weight of the dead bird at so young an age should recommend it to breeders, although it might have been killed one month earlier with advantage, but Mr. Martin thought it better to keep it until the neck-feathers had obtained their proper colouring. I think it would have been in more prime condition and a better weight than at present had it been killed at three months old.

II.—BOTANY.

Art. XIV.—*Revised List of New Zealand Seaweeds.—Part I.*

By Robert M. Laing, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 4th October, 1899.*]

Plates V.-VII.

The following list is based chiefly upon the work of Professor J. G. Agardh, and to a large extent follows the order of his "De Algis Novæ-Zealandiæ marinis." No general account of the New Zealand seaweeds has been published since 1864, when Hooker's "Handbook of the New Zealand Flora" was issued. Agardh's annotated list, referred to above, appeared in the Lund Univ. Årskrift, tom. xiv., 1877. It is to be hoped that the following paper will give New Zealand students a clue to the work that has been done since that date, and will also lay the foundations for a knowledge of the distribution of our species within New Zealand. No attempt is made in it to deal with external distribution, or to give an extended synonymy of the species. It will, however, be found that the list increases the proportion of endemic species, largely because earlier algologists somewhat hastily identified similar forms with European species, as, for example, in the genera *Porphyra* and *Ulva*.

They also too frequently considered such names as "New Zealand," "Australia," "East Coast" as sufficiently descriptive of the habitat. This led to the inclusion, particularly in Hooker's Handbook, of a number of Australian species in our list, and still leads to doubts as to the acceptance of other species not recently collected. In this revision, therefore, I have not included any species of Harvey which have not been accepted by Agardh or collected subsequently to the publication of the "Flora Novæ-Zealandiæ." On this ground also species endemic to the Auckland or Campbell Islands have been excluded, as no recent collections have been made in these groups. My own collections have been made almost entirely on the eastern and southern coasts of both Islands, and include stations intermediate between Mongonui in the

north and Paterson's Inlet (Stewart Island) in the south. For the benefit of future collectors I may mention the following localities as good collecting-grounds: Half-moon Bay (Stewart Island). *South Island*—The Bluff, the Nuggets, Akatore (near Tokomairiro), very good; Brighton, Lower Green Island Beach, St. Clair, good; Moeraki, Akaroa, fair; Taylor's Mistake, fair; Double Corner (Amberley), Kaikoura, very good. *North Island*—Wellington Heads (Lyall's Bay, Island Bay, &c., probably the best collecting-ground in the colony for all forms of shore-life), Castlepoint, Rangitoto Channel, Bay of Islands, very good; Mongonui, fair. There are, no doubt, many other good localities, particularly in the North Island; but a collector visiting any of the above is sure to be well rewarded for his pains.

I have to thank Mr. Crosby Smith, who has collected very carefully in the neighbourhood of Dunedin, for a number of localities for various species, and also for other kind assistance in the preparation of this paper.

Revised List of New Zealand Seaweeds.

Sub-class CYANOPLYCEÆ.

Order **Nostocaceæ.**

1. *Tolypothrix irregularis.* Fl. Nov.-Zel., p. 265.
   On tidal mud, amongst patches of *Vaucheria: Colenso.*

2. *Calothrix scopulorum.* Fl. Nov.-Zel., p. 265.
   Seashores, on rocks and mud; common: *Colenso.*

3. *Lyngbya*, sp., J. Ag., De Alg. N.Z. Mar., p. 1.
   On corallines and other *Algæ*, at Auckland and Bay of Islands: *Berggren.*

4. *Rivularia australis*, Harv. (Harvey Gibson, Journal of Botany, June, 1893).

Sub-class CHLOROPHYCEÆ.

Order **Caulerpaceæ.**

5. *Caulerpa articulata.* Fl. Nov.-Zel., p. 261.
   East Coast: *Colenso.*

6. *Caulerpa lætevirens*, var., J. Ag. ("Till Algernes Systematik," J. Ag., p. 34) (*Caulerpa sedoides:* Fl. Nov.-Zel., p. 261).
   Lyall's Bay: *Lyall; Berggren; R. M. L.* Moeraki: *R. M. L.*
   This species has only been imperfectly described, and requires further examination. It is very abundant in the deep tidal pools in the neighbourhood of Island and Lyall's Bays, Wellington.

7. *Caulerpa brownii.* J. Ag. (*C. brownii* and *C. furcifolia*: Fl. Nov.-Zel., p. 260).
Lyall's Bay: *Lyall.* Bluff, Warrington, Banks Peninsula, Lyall's Bay: *Berggren.* St. Clair, Kaikoura, Lyall's Bay: *R. M. L.* Green Island Beach: *J. C. S.* Chatham Islands: *Travers; Dr. Schauinsland.*

8. *Caulerpa hypnoides.* Fl. Nov.-Zel., p. 260.
East Coast: *Colenso.* Bay of Islands: *Berggren.*

Order **Codiaceæ.**

9. *Bryopsis vestita,* J. Ag., De Alg. N.Z. mar., p. 3 (*B plumosa*: Fl. Nov.-Zel., p. 261 ?).
Bluff, Warrington: *Berggren.* Lyttelton, Wellington: *R. M. L.* St. Clair, Green Island Beach: *J. C. S.*

10. *Codium adhærens.* Fl. Nov.-Zel., p. 261.
Everywhere abundant.

11. *Codium tomentosum.* Fl. Nov.-Zel., p. 261.
Everywhere abundant.

Order **Cladophoraceæ.**

Our New Zealand species of *Cladophora* are in need of careful revision. I have several in my collection which I find it impossible to identify, one at least probably new. The species are nearly all difficult of discrimination, and have been but little collected. As it is almost impossible to name them without type specimens, the following list of species is copied from Agardh's De Algis Nov.-Zel. mar. I have, however, inserted, somewhat hesitatingly, two species not previously recorded in any New Zealand list—*C. feredayi* and *C. valonioides*. The identification of the latter is due to Kjellman. Mr. Crosby Smith was the first to call my attention to the former. He obtained a specimen of it at the lower Green Island Beach. Since then I have collected it myself at various more southern localities. It seems to be identical with the Australian species (Harvey, Phyc. Aust., vol. i., pl. 47). I sent a named specimen of it to Professor Agardh, who noted it "*C. feredayi, forsitan ita.*"

12. *Cladophora crinalis.* Fl. Nov.-Zel., p. 263.
New Zealand: *Colenso.* Half-moon Bay: *R. M. L.*

13. *Cladophora gracilis.* Fl. Nov.-Zel., p. 263.
Port William: *Lyall.*

14. *Cladophora daviesii.* Fl. Nov.-Zel., p. 263.
Tauranga: *Colenso; Berggren.*

15. *Cladophora colensoi.* Fl. Nov.-Zel., p. 262.
Hawke's Bay : *Colenso.*

I have a specimen from the Kaik, Otago Harbour, collected by Mr. Crosby Smith, which apparently belongs to this species.

16. *Cladophora verticillata.* Fl. Nov.-Zel., p. 262.
Port William : *Lyall.*

17. *Cladophora pellucida.* Fl. Nov.-Zel., p. 262.
Waitemata Harbour : *Lyall.* The Bluff : *R. M. L.*

18. *Cladophora feredayi (?).* Harv., Phyc. Austr., vol. i.
Lower Green Island Beach : *Crosby Smith.* The Nuggets, the Bluff : *R. M. L.*

This may only be a much laxer form of *C. pellucida*, growing in deeper water.

19. *Cladophora lyallii.* Fl. Nov.-Zel., p. 262.
South Island : *Lyall.* Half-moon Bay : *J. C. S.; R. M. L.*

20. *Cladophora herpestica.* Fl. Nov.-Zel., p. 262.
Bay of Islands : *Hombron; Hooker.*

21. *Cladophora valonioides*, Sond. (Harvey Gibson, Journal of Botany, June, 1893).

22. *Lychæte longearticulata*, J. Ag., De Alg. N.Z. mar., p. 2.
Banks Peninsula : *Berggren.*

23. *Lychæte linum.* Fl. Dan. and C. Ag. Syst., p. 97 (*Conferva ærea :* Fl. Nov.-Zel., p. 263 ?).

Tauranga : *Berggren.* The Bluff, Lyttelton, Wellington : *R. M. L.*

24. *Lychæte darwinii.* Fl. Nov.-Zel., p. 263.
East Coast : *Lyall; Colenso.* Bluff, Warrington, Banks Peninsula : *Berggren.* Akatore, St. Clair, Taylor's Mistake, Kaikoura : *R. M. L.* Chatham Islands : *Dr. Schauinsland.*

Order **Ulvaceæ.**

25. *Ulva rigida*, Ag. (*Ulva lobata* and *Ulva latissima*, Harv., Fl. Nov.-Zel., p. 265).

Everywhere common.

26. *Ulva bullosa*(?), Roth., Fl. N.Z., ii., p. 265.

I have specimens gathered at Happy Valley and Oriental Bay, Wellington, apparently to be referred to the plant designated by Harvey "*Ulva bullosa*(?)." This identification is, however, more than questionable. *Ulva bullosa*, Roth., is now *Monostroma bullosum*, J. Ag. (Till Alg. Syst., part iii., p. 97). On forwarding specimens collected by myself to Agardh, he considered them as probably nearer the doubtful species—*Ulva cornucopiæ.*

27. *Enteromorpha bulbosa* (Suhr in Flora, 1839, p. 72), J. Ag., Till Alg. Syst., iii., p. 139.
Chatham Islands.

28. *Enteromorpha lingulata*, J. Ag., Till Alg. Syst., iii., p. 143.
Intermediate between *E. compressa* and *E. clathrata*. Probably common.

29. *Enteromorpha compressa*. Fl. Nov.-Zel., ii., p. 264.
This is said to be a cosmopolitan species, but of this Agardh is doubtful (Till Alg. Syst., iii., p. 137), and does not include New Zealand in the list of localities from which he has authentic specimens. This may be an omission, as he recognises it in his De Alg. N.Z. mar.

30. *Enteromorpha linza*.
Chatham Island: *Dr. Schauinsland*.

31. *Enteromorpha clathrata*. Fl. Nov.-Zel., ii., p. 265.
Bluff, Lyall's Bay, Tauranga: *Berggren*. St. Clair: *J. C. S.* Oriental Bay, Evans Bay, Lyttelton: *R. M. L.*

32. *Enteromorpha ramulosa* (Engl. Bot., tab. 2137), J. Ag., Till Alg. Syst., iii., p. 154.
Otago Harbour: *Lyall*.

33. *Enteromorpha acanthophora* (Kuetz., Sp. Alg., p. 479.) J. Ag., Till Alg. Syst., iii., p. 157.
New Zealand: *Berggren*. Chatham Islands: *Dr. Schauinsland*.

34. *Enteromorpha minima*. Kuetz., Sp. Alg., p. 482.
Chatham Islands: *Dr. Schauinsland*.

The species belonging to the subdivision *Clathrata* (genus *Enteromorpha*) are still in much confusion, and only careful collection throughout the colony is likely to enable us to group them properly.

35. *Porphyra nobilis*. J. Ag., Till Alg. Syst., iii., p. 62.
New Zealand: *Berggren*. Common.

36. *Porphyra columbina*: J. Ag., Till Alg. Syst., iii., p. 70 (Mont., Prodr. Phyc. Ant., p. 14). Common. *P. laciniata*: Harv., Fl. Nov.-Zel., p. 264.

37. *Bangia ciliaris*. Fl. Nov.-Zel., p. 264.
"On leaves of *Zostera*, Cook Strait: *Lyall*."
This plant has not been collected recently.

38. *Bangia lanuginosa*. Fl. Nov.-Zel., p. 264.
On *Chordaria*: *Colenso*. Not collected recently.
I have a distinct species of *Bangia*, from the bridge on the Purakino River.

Sub-class PHÆOPHYCEÆ.

Order **Ectocarpaceæ.**

(The New Zealand species are but little known.)

39. *Ectocarpus pusillus.* Fl. Nov.-Zel., p. 222.
Hawke's Bay : *Co'enso.*

40. *Ectocarpus confervoides.* Fl. Nov.-Zel., p. 222.
Otago and Blind Bay : *Lyall.*

41. *Ectocarpus siliculosus.*
Bay of Islands : *Hooker.* Port Cooper and Port William : *Lyall.* Tauranga : *Davies.* Lyttelton : *R. M. L.* Cape Kidnapper : *Colenso.* St. Clair, Puketeraki : *J. C. S.*

Order **Sphacelariaceæ.**

42. *Stypocaulon funiculare (Sphacelaria funiculare).* Fl. Nov.-Zel., p. 221.
Akaroa : *Hombron* and *Lyall.* Taylor's Mistake : *R. M. L.* East Coast : *Colenso.* St. Clair (fairly common) : *J. C. S.*

43. *Stypocaulon paniculatum (Sphacelaria paniculatum).* Fl. Nov.-Zel., p. 221.
Everywhere abundant.

44. *Sphacelaria botryoclada.* Fl. Nov.-Zel., p. 221.
East Coast and Cook Strait : *Lyall.* St. Clair : *J. C. S.*
Agardh doubtfully identifies some specimens collected at the Bluff as belonging to this species.

45. *Anisocladus congestus*, Rke. (Harvey Gibson, Journal of Botany, June, 1893).
French Pass : *Dr. Schauinsland.*

Order **Chordariaceæ.**

46. *Herponema pulvinatum*, J. Ag., Till Alg. Syst., i., 56 (*Sphacelaria pulvinata :* Fl. Nov.-Zel., 221).
In the receptacles of *Carpophyllum : Colenso.* St. Clair : *J. C. S.*

47. *Herponema maculans*, J. Ag., Till Alg. Syst., i., 56 (*Elachista maculæformis*, J. Ag., Alg. Nov.-Zel., p. 4).
On *Fucodium chondrophyllum : Berggren.*

48. *Myriocladia chorda*, J. Ag., Till Alg. Syst., i., p. 18 (*Chordaria sordida :* Fl. Nov.-Zel. (?)).
Probably common.

49. *Corynophlœa cystophoræ*, J. Ag., Till Alg. Syst., i., p. 22; Harvey Gibson, Journal of Botany, June, 1893.
The Bluff, Moeraki, Kaikoura, Lyall's Bay, Bay of Islands (probably common) : *R. M. L.* French Pass : *Dr. Schauinsland.*

50. *Corynophlœa umbellata*, J. Ag., Till Alg. Syst., i., p. 21; Harvey Gibson, Journal of Botany, June, 1893.

51. *Mesogloia intestinalis.* Fl. Nov.-Zel., p. 220.
Blind Bay, Auckland, Otago Harbour: *Lyall.*

I have a plant collected at Dunedin by Mr. J. Crosby Smith which may belong to this species, but the original identification of the genus is more than open to suspicion.

52. *Leathesia difformis*, L. Aresch. Phyc. Scand., p. 376.
French Pass: *Dr. Schauinsland.*

This is probably *Leathesia berkleyi* (Fl. Nov.-Zel., p. 220). The plant is common throughout the Islands. I have observed it at various places between Half-moon Bay, Stewart Island, and Mongonui.

53. *Scytothamnus australis.* Fl. Nov -Zel., p. 219.
Everywhere plentiful on tidal rocks. The position of the genus is uncertain.

Order **Encœliaceæ.**

(Murray, " Introduction to Study of Seaweeds, p. 104.)

54. *Asperococcus sinuosus.* Fl. Nov.-Zel., p. 219.
Everywhere plentiful near high-water mark.

Order **Laminariaceæ.**

55. *Adenocystis lessoni.* Fl. Nov.-Zel., p. 218; Phycological Memoirs, x. (Brit. Mus.).

An annual, everywhere abundant between the months of October and May. The best specimens, however, come from the South Island. The finest I have seen were growing on tidal flats, Wyckliffe Bay, Otago Peninsula.

56. *Ecklonia richardiana.* Fl. Nov.-Zel., p. 218.
This is apparently the common species of *Ecklonia*, wrongly referred to in Hooker's Handbook as *E. radiata.*

Lyttelton: *R. M. L.* Hawke's Bay: *Colenso.* Lyall's Bay, Bay of Islands: *Berggren.*

57. *Ecklonia radiata.* Fl. Nov.-Zel., p. 217.
The occurrence of this plant in New Zealand is somewhat doubtful. I have a juvenile specimen from the Bay of Islands which possibly belongs to this species, and Agardh has specimens from the Chatham Islands which he also doubtfully refers to *E. radiata* (De Alg. N.Z. Mar., p. 6).

58. *Ecklonia exasperata.* Fl. Nov.-Zel., p. 217.
New Zealand: *D'Urville; Cunningham; Hooker.* Island Bay, Mongonui: *R. M. L.*

59. *Ecklonia brevipes*, J. Ag., De Alg. N.Z. Mar., p. 5.
Bay of Islands (very sparingly): *Berggren.*

60. *Ecklonia flabelliformis*. Fl. Nov.-Zel., p. 218.
Wangari Bay: *D'Urville*. Bay of Islands: *Hooker*.

The species of this genus (*Ecklonia*) are still insufficiently defined. Juvenile forms vary so much from older forms that until series at all stages of development have been collected we are not likely to be able to classify them properly.

61. *Lessonia variegata*, J. Ag., De Alg. N.Z. Mar., p. 6; R.M.L., Trans. N.Z. Inst., vol. xxvi., p. 304.

Akatore, the Nuggets, Lyall's Bay, Kaikoura (in rock-pools): *R. M. L.* One specimen, in drift-weed, Tumble-down Bay, Banks Peninsula: *R. M. L.* Whangaruru; *H. B. Kirk!*

This plant is only found in deep rock-pools at more or less isolated spots on the coast-line. It does not occur in the neighbourhood of Lyttelton or Dunedin. It is very plentiful in the neighbourhood of Wellington, where, however, the Makara Stream (Mr. Kirk informs me) is the western boundary of its habitat. The immense tree-like South American *Lessonias* have not yet been authentically recorded from New Zealand.

62. *Macrocystis dubenii (M. pyrifera)*. Fl. Nov.-Zel., p. 217.

This plant is generally reported as everywhere abundant on the New Zealand coast, but I was unable to find it on the east coast of the North Island, though I looked for it at the following ports: Napier, Gisborne, Auckland, Whangaroa, Bay of Islands, Mongonui. I have not been able to find any specimens of the extraordinary length mentioned by the earlier voyagers. The longest I have actually measured was about 100 ft. in length; but the stems were then so twisted into cables that it was impossible to say whether they belonged to one plant or several.

63. *Chorda lomentaria*. Fl. Nov.-Zel., p. 218.

Everywhere plentiful on tidal flats, and in shallow rock-pools.

Order **Sporochnaceæ.**

64. *Sporochnus stylosus*. Fl. Nov.-Zel., p. 216.
"Otago Harbour and Foveaux Strait: *Lyall*."

This plant has not been collected recently, and its occurrence in New Zealand may be considered somewhat doubtful.

65. *Perithalia capillaris*, J. Ag., Till Alg. Syst., vi., p. 5.
Barrier Island, Thames: *Colenso*.

66. *Carpomitra cabreræ*. Fl. Nov.-Zel., p. 217.
Lyall's Bay: *Lyall*. Hawke's Bay: *Colenso*. Chatham Islands, Kaikoura, Lyttelton: *R. M. L.*

67. *Carpomitra halyseris.*

Bay of Islands: *Cunningham; Sinclair; Lyall; Hooker.* Lyall's Bay: *Berggren.*

Harvey Gibson (Journal of Botany, June, 1893) considers this only a variety of the preceding.

Order **Splachnidiaceæ.**

68. *Splachnidium rugosum.* Fl. Nov.-Zel., p. 215; Phyc. Mem. (Brit. Mus.), i., Miss M. O. Mitchell and Miss F. G. Whitting; Trans. N.Z. Inst., vol. xxv., p. 288, R. M. L.

An annual, everywhere abundant except during winter months, on tidal rocks.

Order **Dictyotaceæ.**

69. *Glossophora harveyi*, J. Ag., Till Alg. Syst., ii., p. 111. (*Dictyota kunthii:* Fl. Nov.-Zel., p. 219).

New Zealand and Chatham Islands. Common.

Agardh (*loc. cit.*) retains the specific name *kunthii* for the South American plant, with which the New Zealand one was formerly considered identical.

70. *Dictyota dichotoma.* Fl. Nov.-Zel., p. 219.

Hawke's Bay: *Colenso.* Queen Charlotte Sound: *Lyall.* Bay of Islands: *Berggren.*

It is very doubtful whether this plant is identical with the European *D. dichotoma.* It may possibly be *D. radicans*, Harv., but I have not seen any specimen which agrees with *D. radicans* "in rooting by scattered thread-like fibres issuing from the stipes and lamina"; but see J. Ag., Till Alg. Syst., ii., 92. Indeed, I am by no means certain that we have in New Zealand any species of *Dictyota*, as it is quite possible that immature specimens of *Glossophora harveyi* have been confused with *D. dichotoma.* Although Agardh states (De Alg. N.Z. mar., p. 5) that *D. dichotoma* was collected at the Bay of Islands by Berggren, he does not recognise this habitat in his Till Alg. Syst. I have in my herbarium an immature specimen of *Glossophora* from the Bay of Islands which I long mistook for a species of *Dictyota.* Previous writers may have done similarly.

71. *Zonaria turneriana*, J. Ag., Till Alg. Syst., i., 48 (*Zonaria interrupta:* Fl. Nov.-Zel. p. 218).

The New Zealand species is distinct from the South African *Z. interrupta*, with which it was formerly confused (J. Ag.).

Common on tidal rocks about low-water mark.

72. *Zonaria sinclairii.* Fl. Nov.-Zel., p. 218.

This plant was originally described by Harvey from specimens sent from New Zealand, but does not seem to have been collected in New Zealand since. I have one of the specimens distributed by Harvey, and think that it may turn out to be only a form of *Z. turneriana.* A careful collection of specimens of *Zonaria* in the neighbourhood of Wellington would probably settle the point as far as New Zealand is concerned.

73. *Zonaria velutina.* Fl. Nov.-Zel., p. 218.

Common in rock-pools between tidal limits.

I have a very distinct species of *Zonaria* collected by Mr. Crosby Smith at Dunedin. It may be the Victorian *Z. canaliculata,* but it would be dangerous to name it from a single specimen.

Order **Desmarestiaceæ.**

74. *Desmarestia ligulata.* Fl. Nov.-Zel., p. 217.

Akaroa: *Lyall.* Warrington, Banks Peninsula: *Berggren.* St. Clair: *Crosby Smith.* Kaikoura: *R. M. L.*

Order **Fucaceæ.**

75. *D'Urvillæa utilis.* Fl. Nov.-Zel., p. 216.

This plant as well as *Macrocystis* has generally been reported to be abundant on the New Zealand coast. I was, however, unable to find it at any of the places on the east coast of the North Island already mentioned under *Macrocystis.* It is generally found on rocks exposed to the full force of the breakers.

76. *Notheia anomala.* Fl. Nov.-Zel., p. 215.

Common; parasitic on *Hormosira,* and very rarely on *Fucodium* (Phyc. Mem., Brit. Mus., part ii., Miss M. O. Mitchell).

Miss E. Barton has finished an exhaustive research upon this plant, which will be published immediately in the "Transactions of the Linnæan Society."

77. *Hormosira banksii,* Harv., Fl. Tasm.

α. labillardieri. Fl. Nov.-Zel., p. 215.
Everywhere common between tidal limits.

β. sieberi. Fl. Nov.-Zel., p. 215.
In tidal pools near high-water mark.

78 *Fucodium chondrophyllum,* J. Ag. (*Xiphophora chondrophylla:* Fl. Nov.-Zel., p. 215).

Common on tidal rocks in exposed situations.

79. *Fucodium gladiatum (Xiphophora billardieri).* Fl. Nov.-Zel., p. 215.

It is very questionable whether this plant has been found in New Zealand. Specimens from New Zealand thus named have, according to Agardh, been generally, perhaps always, varieties of the preceding (De Alg. N.Z. mar., p. 7).

80. *Cystophora platylobium*, J. Ag. (*Cystophora lyalli:* Fl. Nov.-Zel., p. 214).

The Bluff (rock-pools), New Brighton (drift-weed), Kaikoura (drift-weed), Wellington Heads (drift-weed): *R. M. L.* Foveaux Strait: *Lyall.* Bluff, Lyall's Bay, Napier: *Berggren.*

81. *Cystophora distenta*, J. Ag., De Alg. Chatham. in Act. Holm.

Chatham Islands: *Travers.* Bluff: *Berggren.* French Pass: *Dr. Schauinsland.*

82. *Cystophora scalaris.*, J. Ag., *ib.*

St. Clair: *Crosby Smith.* Chatham Islands: *Travers.* Bluff, Dunedin, Warrington, Banks Peninsula, Lyall's Bay: *Berggren.*

83. *Cystophora dumosa*, Ag. and Grev.; J. Ag., *l.c.*
Common.

84. *Cystophora retroflexa.* Fl. Nov.-Zel., p. 214.
Abundant.

85. *Cystophora torulosa.* Fl. Nov.-Zel., p. 214.
Common.

86. *Carpophyllum angustifolium*, J. Ag., De Alg. N.Z. mar., pp. 8, 9. Plate V., fig. 1, and Plate VII., *b.*

Bay of Islands (very rare): *Berggren.*

I obtained specimens of this plant apparently from the same tidal pools from which Berggren obtained it. I append a description which will probably be sufficient for systematic purposes (Agardh's specimen did not include rhizoid or bladders): *C. angustifolium*, rhizoid, matted, fibrous, consisting of a mass of anastomosing hapteres, which are expanded at their terminations, and closely appressed to the surface of the rock, forming a disc-like structure; frequently enclosing numerous pebbles, shells, and other extraneous material. From this disc are derived a large number of pendulous flexuous stems, 80–150 cm. in length and 1–2 mm. broad.* This breadth remains constant throughout the whole length, with only a slight tapering at the tips. In transverse section the stem is oval. At distances of from 3–4 cm. short pinnate branches of

* These measurements and the general description apply to the dried specimen only.

from 10–15 cm. in length are given off. At the base of the stem they sometimes reach 40 cm. in length. These are similar in general appearance to the main stem, and bear alternate leaves. They are sometimes themselves again slightly pinnately subdivided. On the lower half of the stem the branches are frequently abraded, leaving only alternate tooth-like projections to mark their original positions. The leaves are somewhat variable in dimensions and shape, 10–20 mm. long and 2–5 mm. broad, linear to lanceolate, and frequently falcate, acute to acuminate, entire or sinuous, ecostate, sessile or very shortly stipitate, thicker and more coriaceous than the leaves of *C. phyllanthus* or *C. maschalocarpum*. Bladders spherical, pear-shaped, or elliptical, apiculate or bearing small leaflets on the summit 1–2 cm. in length, few in number, and replacing the leaves. Receptacles minute, borne in fascicles in the axils of the leaves, the main stem of the fascicle being persistent. I append a photograph of a dried specimen. Plate V., fig. 1.

87. *Carpophyllum phyllanthus*, Turn., Hist., iv., tab. 206. Plate V., fig. 2.; Plate VII., *f, g, h*.

This plant is by no means so common as *C. maschalocarpum*, but it is generally to be found in deep tidal pools anywhere along the coast. As there has been much confusion as to the species of this genus, I give photographs of typical specimens of each, which will enable them to be more readily distinguished than by much description; and also drawings of typical leaves.

88. *Carpophyllum maschalocarpum*, Turn., Hist., iv., tab. 205. Plate VI., fig. 1, 2, and Plate VII., *a, c*.

Everywhere abundant.

This plant is ordinarily very distinct from the previous, but intermediate forms are sometimes found. There are many varieties; to one distinct form I propose to give the name "*laxum*."

C. maschalocarpum, var. *laxum*, R. M. L. This differs from the ordinary form in the more sinuous stems, much more open habit, narrower, more acute, sometimes acuminate leaves. It is apparently distinct also in its habitat, as I have only found it growing at the Sugar-loaves, Taranaki, and in the drift-weed occasionally at Island Bay (Wellington). Intermediate forms exist between this and the common form. I append a photograph of the plant.

89. *Carpophyllum plumosum*, J. Ag. (*Sarg. plumosum*: Fl. Nov.-Zel., p. 212). Plate VI., fig. 3, and Plate VII., *d, e*.

Many previous collectors have stated that this plant is very common on the New Zealand coasts. Berggren collected it

at Lyall's Bay, Napier, Tauranga, Hokianga, Bay of Islands, but it seems to me to be distinctly a northern form. I have no specimens from the South Island, and found it increase in abundance from Wellington to Auckland in the North Island. In the Rangitoto Channel in January I found it to be the most abundant of all the *Fucaceæ*.

90. *Marginaria boryana.* Fl. Nov.-Zel., p. 213.
Bluff, Dunedin, Banks Peninsula: *Berggren.* Sumner, St. Clair, Kaikoura: *R. M. L.*

91. *Marginaria urvilleana.* Fl. Nov.-Zel., p. 214.
Banks Peninsula: *Lyall.* Castlepoint: *Colenso.* Bluff, Lyall's Bay: *Berggren.* Kaikoura: *R. M. L.*

92. *Landsburgia myricifolia,* J. Ag., Alg. Chatham Is.

93. *Landsburgia quercifolia.* Fl. Nov.-Zel., p. 213.
Bay of Islands: *D'Urville; Colenso; Hooker; Lyall.* Bluff, Lyall's Bay, Napier, Hokianga: *Berggren.* Sumner, Kaikoura, New Plymouth: *R. M. L.*

94. *Sargassum sinclairii.* Fl. Nov.-Zel., p. 211.
Everywhere common.

95. *Sargassum verruculosum (Sarg. raoulii).* Fl. Nov.-Zel., p. 212.
Akaroa: *Raoul.* Bluff: *Berggren.* Stewart Island, Kaikoura: *R. M. L.*
This is one of the rarest of our *Fucaceæ.* I have other species of *Sargassum,* from Stewart Island and the Bay of Islands; but, as this is one of the most difficult of all the genera of the *Algæ,* I hesitate identifying them without abundance of material.

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4. "Till Algernes Systematik," parts i., ii., iii., and vi., 1872. (J. G. Agardh.)

5. "Om Chatham-öarnes Alger," 1870. (J. G. Agardh.)

6. "On some Marine Algæ from New Zealand," 1893. (R. J. Harvey Gibson), Journal of Botany, vol. xxxi.

7. "Ergebnisse einer Reise nach dem Pacific." (Professor Dr. Schauinsland, 1896–97.) Meersalgen von Th. Reinbold. (Sonder-Abdr. a Abh. Nat. Ver. Brem., 1899, Bd. xvi., H. 2.)

EXPLANATION OF PLATES V.-VII.

PLATE V.

Fig. 1. *Carpophyllum angustifolium*, J. Ag. Bay of Islands; collected in January; *R. M. L.*

Fig. 2. *Carpophyllum phyllanthus*, Turn., Hist., iv. Both specimens are from the same plant, which was gathered at Lyall's Bay in the month of September.

PLATE VI.

Fig. 1. *Carpophyllum maschalocarpum*, Turn., Hist., iv. Collected at Lyttelton in the autumn; *R. M. L.*

Fig. 2. *Carpophyllum maschalocarpum*, var. *laxum*, R. M. L. Sugar-loaves, Taranaki; January; *R. M. L.*

Fig. 3. *Carpophyllum plumosum*, J. Ag. Bay of Islands; January; *R.M.L.* The winter form differs from this considerably (see Plate VII., fig. *e*).

PLATE VII.

a. *Carpophyllum maschalocarpum* (tip of frond).
b. *C. angustifolium* (tip of frond).
c. *C. maschalocarpum*, var. *laxum* (tip of frond).
d. *C. plumosum* (tip of frond; summer form).
e. The same, winter form.
f., *g*. Basal leaves of *C. phyllanthus*.
h. Leaf from upper portion of plant.
All natural size.

ART. XV.—*On New Lichens from Australia and New Zealand.*

By JAMES STIRTON, M.D., F.L.S., &c.

(Continuation of Paper in Trans. N.Z. Inst., vol. xxx., p. 382.)

Communicated by T. W. Naylor Beckett, F.L.S.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1899.*]

Sticta rubella, Hook., presents obstacles to a complete determination, inasmuch as the original specimens are barren. Nylander in his Lich. N.Z. (1889) merely mentions two new stations for the plant, without giving a description of the apothecia or spores, leading to the inference that these are also barren.

In a parcel of lichens sent several years ago by the late Baron F. von Mueller there is a *Sticta* in fruit, whose characters are nearly identical with those given by Nylander in his Synopsis Meth., page 361. I am extremely sorry I can only discriminate two or three of the specimens in this parcel. The rest seem to have been soaked, almost macerated, in

water for some time, and are accordingly nearly unavailable for diagnosis.

As the spores in Müller's specimen are almost unique (as regards the genus) in their internal organization, I prefer to describe this lichen apart, more especially as I have already described another (Trans. Roy. Soc. Victoria, 1880) from Queensland, sent by Mr. F. M. Bailey, under the name *Parmosticta rubrina*. The thallus of Mr. Bailey's lichen has also characters analogous to those of *St. rubella*, but has spores of quite a different construction from those of Baron Müller's specimen. There are short white hairs on the margin and neighbouring upper surface of the laciniæ, as described by Nylander, *l.c.*, and otherwise the characters are not dissimilar.

Parmosticta purpurascens, Strn.

Apothecia rufa marginalia, elevata, cupuliformia, magna (latit. 4–8 mm.), receptaculum thallinum extus rubricosum, vix rugulosum, interdum læve, supra, late citrino-sorediosum, inflexum; sporæ 4–8næ, fuscæ vel fusco-rufæ, oblongo-ellipsoideæ vel obtuse fusiformes, 4-loculares (loculis subquadratis et inter se tubulo junctis), interdum etiam 3-septatæ, 0·028–0·03 × 0·01–0·013 mm.; paraphyses distinctæ. Iodo g.h. bene cærulescens.

The extremities of the spores are often nearly colourless and almost papilliform. There appear to be two kinds of gonidia; one kind uniformly small, 0·005–0·009 mm. diam.; the other large, 0·012–0·028 mm. diam., with yellow granular contents.

Sticta lorifera, Strn.

Similis *St. impressæ*, Tayl., et similiter laciniata sed supra cephalodiis numerosis, pallidis, fere globosis adspersa; medulla alba vel pallida, K flavens; subtus nigricans, versus marginem pallidior, dense et breviter nigro-rhizinosa et pseudocyphellis parvis pallidis vel interdum albido-flavis; apothecia nigra primum marginata dein immarginata, plana, marginalia, receptaculo extus rugoso vel papilloso-aspero. Gonidia diam., 0·008 – 0·016 mm. New Zealand, prope Wellington (*J. Buchanan*).

This lichen is included under what Nylander calls "*St. physciospora*," but which I hold should be called "*St. impressa*, Tayl." The spores are fuscous, shortly polari-bilocular, rarely 4-locular, and 0·022–0·028 × 0·008–0·01 mm. The thallus is divided almost to the base into long, narrow, tapering laciniæ, which are scarcely transversely costate, and only show such ribs near the base. This lichen, so abundant in New Zealand, shows wonderful diversity of aspect, and the present is one of the most characteristic.

Sticta expansa, Strn.

Thallus amplus, interdum fere pedalis, cervinus vel cinereo-fuscescens, late laciniato - lobatus lobis sæpe imbricatis, scrobiculato - fossulatus vel reticulatim costatus, subtus ochraceus, centrum versus obscurior et ibi obscure vel nigricanti-tomentosus, pseudocyphellis parvis, citrinis creberriter adspersus, intus albus; apothecia sparsa nigra mediocria, margine integro vel fere integro cincta; sporæ 8næ, fuscæ, 2-loculares, sæpe breviter polari - biloculares, 0·02–0·027 × 0·007–0·0085 mm. Gonidia fere leptogonidia parva, diam. 0·005–0·008 mm. (raro 0·009 mm.) contentis non granulatis. Corticola prope Wellington (*J. Buchanan*).

This is closely allied to *St. glaucolurida*, Nyl., and may be its completely developed condition. If so, Nylander's lichen may be called a variety of it under the same name. There is no reaction by K on the medulla.

There is scattered over the upper surface of this *Sticta* a parasitic *Verrucaria*, which may be described.

Verrucaria simplicior, Strn.

Perithecium sessile, nigrum, minutum fere sphæricum, prominulum; sporæ 8næ, incolores, simplices, oblongæ, 2-nucleatæ, 0·009 – 0·011 × 0·003 – 0·004 mm.; paraphyses nullæ. Iodo g.h. non tincta.

Sticta grandis, Strn.

Thallus firmus crassiusculus mediocris (latit. 5–9-pollicaris) rufescenti-cervinus vel rufescens, læviusculus vel versus marginem leviter corrugatulus, laciniato-lobatus lobis sinuoso-divisis, margine hinc inde, et paululum supra, albo-pilosus, subtus nigricans et versus marginem ochraceus vel ochraceo-pallidus, breviter nigricanti - tomentosus, pseudocyphellis parvis citrinis ornatus; medulla alba K – ; apothecia sparsa, cæsio-pruinosa, detrita nigra (latit. 2–5 mm.) receptaculo thallino extus papilloso-aspero, margine primum inflexo et lacerato dein dentato, demum fere depresso; sporæ 8næ, fuscæ, fusiformes, 1-septatæ, sæpius breviter polaribiloculares, 0·025–0·034 × 0·007–0·01 mm. Gonidia flavescentia, diam. 0·007–0·015 mm. Oxford Bush, New Zealand (*T. W. N. Beckett*).

This curious lichen presents characteristics in common with *St. pubescens*, Müll. Arg., *St. granulata*, Bab., *St. glaucolurida*, Nyl., and *St. obvoluta*, Ach. How far we are warranted in retaining these lichens as distinct species is an open question. Meanwhile, in accordance with modern ideas of specific distinction, I have no alternative but to keep them apart. Certainly the present is the most perfectly developed of the group.

Sticta elatior, Strn.

Similis *St. fossulatæ* sed thalla, supra, pallido vel glaucescenti-pallido, subtus ochraceo, centro nigricante. Apothecia cæsio-pruinosa, detrita, nigra; sporæ 8næ fuscæ, obtuse fusiformes, 2-loculares, vix polaribiloculares, interdum tenuiter 1-septatæ, 0·022–0·027 × 0·008–0·01 mm.; medulla pallida vel pallido-albida, K sordide flavescens vel vix colorata. Gonidia flavescentia, 0·009–0·014 mm. diam. Supra thallum cephalodia numerosa fere sphæroidea, intus fibrosa fibrillis fere rectus hinc inde constricta. New Zealand, prope Wellington (*J. Buchanan*).

The cephalodia are (in the specimen) very numerous, and of a pale flesh-colour.

Sticta orygmæa, Ach., var. **calvescens,** Strn.

Similis *St. orygmææ* sed subtus nuda. (New Zealand.)

Sticta parvula, Strn.

Thallus sordide et pallide virescens vel demum fulvescenti-pallescens (latit. 1–2-pollicaris), lævis, fere omnino laciniatus laciniis (latit. 2–4 mm.) planis linearibus divaricato—et sinuoso—multifidis, apice retusis, subtus lutescens vel ochraceo-lutescens, nudus, lævis vel minute rugulosus. Gonidia flavescentia majuscula, diam. 0·012–0·02 mm. Sterilis; Queensland (*C. de Burgh*): prope Lachlan River, Australiæ (*Hb. F. von Müller*).

There was seen only one immature fuscescent apothecium with undeveloped spores. There are neither cyphellæ nor tomentum.

Stictina luridoviolacea, Strn.

Thallus pallescenti-luridus vel lurido-fuscescens vel etiam lurido-violaceus, mediocris (latit. 3–5-pollicaris), firmus vel rigescens, laciniato-lobatus lobis crenato-incisis, scrobiculato-foveolatis (fere sicut in *Sticta fossulata*), margine hinc inde minute citrino-sorediosus, intus medulla citrina vel pallide citrina, subtus nigricans, crasse et creberriter rhizinosus rhizinis validis, brevibus, rectis, nigricantibus, pseudocyphellis citrinis minutis præditus; apothecia nigra, mediocria, margine crenato cincta; sporæ fuscæ biloculares, obtuse fusiformes, 0·025–0·03 × 0·008–0·01 mm. Gonimia cærulescentia, globosa vel oblonga, diam. 0·004 – 0·007 mm. Snowy Creek, Ovens River, Australiæ (*Mrs. McCann*).

Here also a tendency is shown to the spores becoming shortly polari-bilocular, with nearly colourless pellucid apices. Allied to *St. gilreæ*, Thunb., but with a citrine medulla, &c.

Stictina suberecta, Strn.

Thallus parvus stipitatus vel substipitatus, erectus vel suberectus (altit. 2–3 centimetrorum), lobato-incisus vel dis-

sectus (lobis rotundis, margine sæpe deflexis), obscure glaucescens vel plumbeo-cinereus, lævis, glomerulis isidioideis, majusculis, cinereo-nigris creberriter inspersus, isidiis stipitatis et dendroideo-ramosis, subtus ochraceus vel obscure ochraceus vel versus basin obscurior et ibi costatus, nudus vel fere nudus, cyphellis majusculis pallidis ornatus; apothecia biatorina marginalia et sparsa, badio-rufa, margine pallidiora. Sporæ non evolutæ. Gonimia in glomerulis majusculis contenta. Affinis *St. peltigerellæ*, Nyl. Queensland (*F. M. Bailey*).

Stictina limbata, Smith, var. **subflavida,** Bab.

Dr. Nylander (p. 31, Lich. N.Z. 1889) expresses a doubt of this variety belonging to *St. limbata*, but, inasmuch as Babington speaks of it as having "cyphellas urceolatas," he inclines, on the other hand, to the belief that *subflavida* may belong to it. Professor J. Müller, of Geneva, in his "Lichenes Knightiani," page 6, asserts that this variety is nothing else than *Stictina intricata*, var. *thouarsii*, Del. I cannot accept Dr. Müller's decision. *St. limbata* and *St. thouarsii* are common lichens on the west coast of Scotland, and I am quite familiar with their forms. Babington's variety (of which I possess a specimen) differs in no particular from our Scottish forms, except in its yellow colour above and below. The cyphellæ are identical in both as to their irregular outline, although the New Zealand specimen has cyphellæ somewhat more farinose at the fundus than the Scottish form.

I possess another specimen from Mr. F. M. Bailey, of Brisbane, who gathered it somewhere in his neighbourhood. In this the cyphellæ are small and more farinose, and present, accordingly, more the appearance of pseudocyphellæ than otherwise, while the whole under-surface is of a beautiful yellow colour as well as the tomentum. This I shall meanwhile name *Stictina subcrocea*. Both the lichens are barren; indeed, I am not aware that fruit has ever been found on *St. limbata*, or on any of its forms.

I have also from Mr. Bailey three or four specimens of another *Stictina*, all of which have the granulato-isidiose margin to the thallus so characteristic of *Stictina quercizans*, Ach. The thallus, in all, may be said to be much paler than is usual in *St. quercizans*—viz., "pallidus, pallide lutescens, pallide rufescens, rarius pallide fuscescens"—while its breadth is not more than from 2 in. to 4 in. Beneath the colour may be said to be ochraceous, with a darker tomentum, especially towards the centre. The other characteristics are those of *St. quercizans*. Unfortunately, all the specimens are barren. One peculiarity, almost unique, the specimens possess in common—viz., the medulla is pale in the upper half and

pale-yellow in the lower. This lower half is coloured a bright-yellow by K, which colour is permanent, and differs very little from citrine after drying. I give the name *Stictina diversa* to this form.

Parmelia brisbanenis, Strn. Roy. Soc. Vict., 1880.

Thallus tenuis, adpressulus glaucescenti–cinereus vel demum pallide cinereus, hinc inde dendritico-isidiosus, laciniatus (K flavens), laciniis margine sæpius dissecto-fimbriatis vel isidiatis, subtus niger rugulosus, nudus, sed hinc inde parce et brevissime rhizinosus, ambitu spadiceus; medulla citrina vel virescenti-citrina (K – C –); sterilis. Corticola prope Brisbane (*F. M. Bailey*). Affinis *P. sulphuratæ*, Flot.

· **Parmelia permutata,** Strn. Scot. Nat., 1878.

Thallus pallidus vel pallide glaucescens, lævigatus, lobato-divisus, subtus niger, ambitu pallide spadiceus, parce rhizinosus; medullæ pars supera, alba (C leviter erythrinosa), pars infera leviter flavescens (K flavens). Apothecia ignota. Ad ramulos arborum prope Brisbane (*F. M. Bailey*).

Parmelia euplecta, Strn. Scot. Nat., 1878.

Thallus pallidus vel pallide virescens, adpressulus, sæpe sorediiferus, lobato-divisus, subtus niger, parce rhizinosus, ambitu fuscescens; medullæ stratum superius, album (K flavescens), inferius tenue, flavescens vel pallide flavescens (K rubens vel aurantiaco-rubens). Sterilis. Ad ramulos prope Brisbane (*F. M. Bailey*) et in Bahia (*Moseley*).

The specimen from Bahia has a paler thallus and is not sorediiferous, but it is very small and not in good condition.

Parmelia caperata, Ach., is fairly well represented in Australia, although less so in New Zealand. It does not, as a rule, assume the dimensions of European specimens, but is often detected in a diminutive form, to which Nylander has given the name *P. caperatula*, without, however, appending any description otherwise than "minor, elegantula." Again, in Linn. Journ., 1879, p. 394, Nylander describes another form, from the Derwent River, of Australia, under the name *P. subcaperatula*, differing mainly, as stated by himself, from *P. caperata* in having smaller spores. I have numerous specimens of what may be reckoned this form, but the size of the spores is very variable; accordingly scarcely any distinction can be founded on this item. The spermatia give a somewhat more definite result, inasmuch as he states them to be subbifusiform and 0·005–0·007 × 0·0005 mm.

The following has differently shaped spermatia, and seems tolerably common:—

Parmelia obversa, Strn.

Thallus flavescens vel ochroleucus, adpressus, parvus, rugosus vel potius corrugatulus, margine laciniatus et crenulatus, subtus niger vel nigricans, parce nigro-fibrillosus; apothecia fusco-rufa, parviuscula, margine thallino, integro, sæpe inflexo cincta; sporæ 8, variantes, oblongæ vel oblongo-ellipsoidæ, 0·013–0·02 × 0·006–0·008 mm. Spermogonia fere integre nigra, spermatia cylindrica vel exacte cylindrica, recta, 0·006–0·009 × circ. 0·0007 mm. Ad cortices et præsertim ad lignum decorticatum. Thallus supra K flavens; medulla alba K – C –.

In the various collections of lichens from Australia there are several *Parmeliæ* growing on charred wood, which have very curious and constant chemical reactions on the white medulla. Unfortunately, all the specimens are barren. I cannot, however, pass them over on this account.

Parmelia exoriens, Strn.

Thallus pallidus vel lutescenti-pallidus, rugulosus, membranaceus, laciniatus, laciniis margine crenatis et srediosis, subtus pallidus vel hinc inde nigricans, parce radiculosus; medulla alba crassiuscula, K obsolete violaceus dein. C addito, leviter sed distincte rubro-purpurascens vel magenta. Sterilis. Ad lignum carbonizatum, prope Brisbane (*F. M. Bailey*) et in New South Wales (*Kirton*).

The reaction by C, especially after the application of K, is constant, and may be called a faint but decided reddish-purple, or of the colour of magenta. These reactions resemble those on the medulla of *P. caperata*, but there is, in addition, the reaction by K, which on *caperata* is negative, while the after reaction by C on the same is a faint pink colour.

Parmelia redacta, Strn.

Similis præcedenti sed thallo magis adpresso, pallido vel albido et cæsio-soredioso. Illawarra, New South Wales (*Kirton*).

Parmelia hypoxantha, Strn.

Thallus pallide ochroleucus vel etiam pallidus (K flavens) sæpe orbicularis, mediocris, rugosus, laciniatus laciniis parvis, imbricatis, margine crenulatis et sinuoso-lobatis, subtus niger, parce et breviter nigro-radiculosus; medulla alba (K – C –); apothecia fusca (latit. 2–5 mm.), plana, margine sæpius crenulato; sporæ 8, incolores, simplices, late ellipsoideæ, 0·009–0.012 × 0·007–0·009 mm.; hypothecium incolor. Corticola, prope Warwick, Queensland (*C. J. Gwyther*).

The lower surface of the medulla (exposed after the black hypothallus is peeled off) is almost always seen yellow or

orange-yellow, and K gives on this surface a yellow thin red reaction.

This *Parmelia* is certainly closely allied to *P. subtiliacea*, Nyl. (Lich. N.Z., 1889, p. 26), but the spores, in five different examples examined, are as given above, while those of *P. subtiliacea* are 0·014–0·017 × 0·007–0·008 mm., and the "thallus albidus." Krempelhüber describes ("Novara" Exp., p. 114) a *Parmelia* under the name *P. jelinekii*, which is also allied to the present. Its thallus is "ochroleucus," and the submedullary stratum is "late aureum"; but the spores are exactly as given above under *P. subtiliacea*, perhaps a little longer.

I have another small barren specimen, from the Grampian Mountains of Victoria, gathered by Mr. Sullivan, which is remarkable for the peculiar reaction by C on the medulla.

Parmelia violascens, Strn.

Similis *P. conspersæ*, var. *stenophyllæ* sed minor, adpressa et thallo sæpe isidiato; medulla alba K flavens C intense violacea vel coloris magentæ. Color thalli virescenti-lutescens vel lutescens.

Parmelia platycarpa, Strn.

Corticola prope Brisbane (*F. M. Bailey*). This lichen is described in the "Scottish Naturalist" for April, 1878, and, as stated there, is allied to *P. latissima*, Fée. Dr. Nylander, in Lich. Granatæ, vol. i., p. 24, merely mentions a form of *P. latissima*—"thallo flavescenti." Nothing can be founded on this statement. I am still in ignorance of the shape and size of the spermatia of *P. latissima*. Those of *P. platycarpa* are straight, cylindrical, and about 0·006 × 0·0006 mm.

Parmelia cyathina, Strn.

Corticola prope Brisbane (*F. M. Bailey*). Described in the same number of Scot. Nat. This also, as stated, is closely allied to *P. neilgherrensis*, Nyl., and more especially to *P. subrugata*, Nyl. (Exot. Flechten, p. 320); but I can get no information concerning their spermatia. Those of *P. cyathina* are cylindrical, very often curved, and 0·005–0·006 × 0·0009–0·0011 mm.

I have another *Parmelia* from Queensland, gathered by Mr. F. M. Bailey on Darling Downs, whose characters are almost identical with those of another from Sikhim, Himalayas, by Dr. George Watt.

Parmelia confertula, Strn.

Thallus adpressus, substramineus vel flavescens, laciniatus laciniis sæpe imbricatis et margine lobatis et crenatis, subtus niger et densissime nigro-radiculosus (speciminibus Bris-

banensibus parcius radiculosis). Apothecia conferta, rufo-fusca, plana margine integro vel crenulato, et receptaculo thallino subtus rugoso vel foveolato et versus centrum nigro; sporæ 8, incolores, ellipsoideæ, simplices, 0·013–0·017 × 0·008–0·01 mm. Spermatia fere cylindrica, recta, 0·009 × 0·0007 mm.

The reactions of this lichen on the medulla are K – C –, or nearly the same as those of *P. caperata*, which are K – C faintly red.

Parmelia testacea, Strn. Scot. Nat., 1878.

Thallus firmus, adpressulus, pallescens, rufescenti-cinereus vel pallide cervinus, centro squamulosus vel interdum crustaceo-squamulosus, radiato-laciniatus, laciniis sæpe imbricatis, rugulosus, oblongis et lobato-divisis, subtus niger, breviter nigro-rhizinosus; medulla alba K flavens dein intense rubens; apothecia primum concoloria, testacea, demum hepatica, sessilia, plana, majuscula (latit. 4–20 mm.), rotundata, plerumque lobato-incisa (præsertim seniorà), receptaculo extus rugoso; sporæ 8, ellipsoideæ, 0·013–0·018 × 0·008–0·01 mm. Ad saxa (?), prope Wellington, New Zealand (*J. Buchanan*).

This lichen seems allied to *P. saxatilis*, but the thallus is not reticulated, but merely shows here and there very minute depressed soredioid points, &c. The spermatia are bifusiform, 0·006–0·007 × 0·0007–0·0008 mm.

Parmelia erubescens, Strn. Scot. Nat., 1878.

Thallus pallide rufescens vel rufescenti-cervinus, laciniato-lobatus, laciniis rotundatis, margine crenatis vel crenato-incisis et nigro-ciliatis, subtus totus rufo-fuscescens vel etiam cupreus, breviter sed creberriter nigro-rhizinosus; medulla pallida (K flavens dein rubens); apothecia ignota; spermogonia innata extus nigra spermatiis exacte cylindricis, rectis, 0·008–0·01 × circ. 0·0005 mm. Prope Brisbane supra alias *Parmelias* (*F. M. Bailey*).

Although allied to *P. perforata*, the differences indicated above are quite sufficient to warrant a separation. The colour of the thallus seems normal, and not induced, as we see occasionally in *P. perforata*, by extraneous influences. The marginal cilia are much thicker and longer than the rhizinæ, which are finer than usual.

Parmelia conspersa, var. **nigro-marginata,** Strn.

Similis varietati *Stenophyllæ* sed laciniis nigro-marginatis. Thallus subtus niger et fere omnino nudus. Medulla alba K fl. dein rubens et thallus, supra K–. Prope Gippsland, Australiæ (*Lucas*).

Although there is no colouration of the upper thallus by K, yet the red colour produced on the medulla by the same reagent soon shows through.

Parmelia austro-africana, Strn. Trans. Glasgow Field Naturalists, 1877.

Similis *P. conspersæ*, var. *hypoclystæ*, Nyl., sed medulla (K – C leviter erythrinosa; C, seorsum –). Thallus pallidus vel pallide flavescénti-virescens, subtus totus pallidus vel versus ambitum obscurior vel etiam interdum nigricans, parcissime albido-rhizinosus et hinc inde rugulosus; apothecia ampla fusco-nigra, elevato-sessilia; sporæ 8, incolores, ellipsoideæ simplices, 0·008–0·01 × 0·005–0·007 mm. Supra Montes Grampianos Victoriæ (*Sullivan*).

This is evidently distinct from *P. mutabilis*, Tayl., in the colour of the thallus, &c.

Parmelia amplexula, Strn. Proc. Roy. Soc., Victoria, 1880.

Similis *P. austro-africanæ* sed minor et arcte adpressa. Thallus flavescens vel obscure virescenti-flavescens, margine laciniatulus et sæpe isidiosus, subtus nigricans (quantum visus); medulla alba (K – C erythrinosa); sporæ 8, incolores, ellipsoideæ, simplices, 0·008–0·01 × 0·005–0·006 mm.; paraphyses crassæ, breves et quasi interruptæ. Saxicola (*F. M. Bailey*).

That section of the *Parmeliæ* of which *P. pertusa* is the type is well represented in New Zealand and Australia; indeed, better than in any others from which I have obtained lichens. *P. physodes*, L., which may be included in this section, and *P. pertusa* have been already frequently described by different authors. Another I described in the "Transactions of the Glasgow Field Naturalists," 1877, under the name *P. pertransita*. This is allied to *P. pertusa*, but it has smaller spores, and 8 in each theca in place of 2, &c. Mr. Buchanan sent another in 1882, which may be described here.

Parmelia bullata, Strn.

Thallus pallidus vel pallide ochroleucus (K fl. dein rubens), bullato-inæqualis, hinc inde minute terebratus, subtus niger, rugosus, nudus, versus marginem pallidus; medulla tenuis alba (K flavens dein interdum rubens); apothecia elevato-sessilia, cupuliformia, margine thallino extus ruguloso (præsertim maturatarum), epithecio fusco vel fusco-nigro. Sporæ 8, oblongæ, incolores, simplices, episporio crasso hyalino contentis granulosis sæpius lutescentibus, 0·022 – 0·032 × 0·015 – 0·018 mm. Iodo g.h. thecarum cærulescens, caeteroquin vix

tincta. Ad ramos prope Wellington, New Zealand (*J. Buchanan*).

Rarely are there fewer spores in each theca than 8. At times 2 to 4 are seen when the dimensions are somewhat larger.

Parmelia retipora, Strn.

Thallus albidus vel pallide lutescens, arcte adpressus (K flavens), reticulato-terebratus (fere ut in *Cladonia retipora*), latit. divisionum, 0·4 mm.; latit. foraminum circ. 1·6 mm.; subtus nudus et fusco-niger (?); medulla alba K fl.; sporæ 1, raro 2, incolores, ellipsoideæ, simplices parietibus crassis, 0·05 – 0·065 × 0·025 – 0·03 mm., paraphyses fere diffluentes. Corticola in Tasmania a *Mrs. Heywood McEwen* lecta.

Parmelia subbrunnea, Strn.

Thallus brunneo-nigricans (C flavens), adpressus, bullato-inæqualis, bullis sæpissime perforatis, subtus niger, rugulosus, nudus margine albidus. Apothecia fusca margine integro pallidiore cincta; sporæ non evolutæ. Saxicola in Montibus Grampianis Australiæ (*Sullivan*).

The hyphæ are at first colourless; those next the hypothallus are much more numerous and fuscous, and slightly branching, diameter from 0·004 mm. to 0·006 mm. Gonidia 0·008 – 0·016 mm. in diameter. I cannot detect anything morbid in the plant, while the reaction by C on the thallus is constant and peculiar.

Parmelia nigrescens, Strn. Scot. Nat., 1878.

Sat similis *P. pertusæ* sed apotheciis nigris vel cæsionigris et sporis 1–2nis incoloribus dein fuscescentibus, ellipsoideis, simplicibus, episporio incrassato, 0·04 – 0·054 × 0·024–0·038 mm. Iodo g.h. cærulescens dein vinose fulvescens. Supra lignum prope Wellington, New Zealand (*J. Buchanan*).

The epithecium shows as a rufo-fuscous almost continuous layer composed of compacted cells. This may be a state of *P. pertusa*, and, if so, is very peculiar. Even the young apothecia are black. The thallus is pertused, and the white medulla is rendered yellow by K. The thecæ and spores seem to be ultimately tinged rufo-fuscous together, &c.

Parmelia angustata, Pers., seems a common lichen throughout Australia, and extends even pretty far south in New Zealand. Like all common plants, it assumes various appearances, but the size and shape of the spores are constant—viz., 0·005–0·007 × 0·004–0.005 mm.—as well as the dark-brown, often nearly black, spongiose hypothallus, so characteristic of this section of the *Parmeliæ*.

The variety *moniliformis*, Bab., is a well-marked one, inasmuch as the yellow branches as well as the stems are moniliform-constricted throughout. From Beechcroft, Victoria (*Falck*), 1881.

Another rather common form is that where the whole plant is nearly isidiose. This may be called var. *isidiella*.

A third was sent to me by the late Baron F. von Müller from Tasmania. In this the whole plant is pale-brown or cervine in place of a light or pale colour; the stems and branches are flat and narrower than usual (latit. about 1 mm.), and not constricted here and there, and the radicles beneath nearly black, coarser and stronger and not so densely interwoven; apothecia larger in proportion to the stems (latit. 2–6 mm.), usually split all round in a radiating manner. This may be called var. *falckii*.

Lastly, Mr. Beckett sent me from North Canterbury a pale variety, where the yellow colour is scarcely perceptible. This form grew closely intermingled with *P. physodes*.

Aspidelia beckettii, Strn. Gen. nov.

Thallus pallidus vel glaucescenti-pallidus, nitidus, lobato-laciniatus, lobis sinuato-divisis, sorediis albis, innatis, minutis vel punctiformibus vel tenuiter oblongis, creberriter adspersus, subtus fusco-niger vel niger, parce nigro-rhizinosus; apothecia fusco-rufa, sæpe lobulata et medio perforata (latit. 4–11 mm.); sporæ 4–8næ in thecis arthonioideæ, *i.e.*, parietibus crassis hyalinis, incolores, ellipsoideæ, simplices episporio duplici, 0·013–0·018 × 0·008–0·011 mm., paraphyses valde indistinctæ. Iodo g.h. thecarum cærulescens dein sordida, cæteroquin vix tincta nisi lutescens; medulla alba K fl. dein intense rubens. Spermogonia in tuberculis elevatis, irregularibus, rugulosis vel cerebriformibus, discoloribus (lutescentibus vel pallide carneis), hinc inde nigris, interdum majusculis (latit. 0·5–2 mm.) sita, extus nigra minuta, numerosa, 4–25 in quavis verruca; spermatia cylindrica vel apicibus obsolete incrassatulis, 0·006–0·008 × circ. 0·0005 mm. Corticola, New Zealand (*T. W. Naylor Beckett*).

At first sight this lichen has somewhat the appearance of *P. perforata*.

As I have not seen spermogonia clustered in raised tubercles of a diverse colour from the rest of the thallus, and having spores contained in thecæ with thick pellucid walls, I have been constrained to separate this lichen from the *Parmeliæ*.

I possess a second species of this genus from the Himalayas, gathered by Dr. George Watt at an elevation of 12,000 ft., where the clusters of spermogonia are on a larger

scale and in better-defined bullæ. There are besides large cephalodia of a light colour on the upper surface.

Aspidelia wattii, Strn.

Thallus late expansus, pallidus vel pallide lutescens, laciniatus laciniis hinc inde imbricatis, margine sæpe fimbriato-dissectis, subtus niger, fere nudus; medulla alba K— C, erythrinosa et C, seorsum, erythrinosa; sterilis.

In the two examples examined I failed to detect spermatia.

Physcia incavata, Strn.

Thallus orbicularis flavus adpressus, late lobatus lobis crenatis, intus albidis, arachnoideis et interdum cavis (K purpurascentibus); apothecia rufo-aurantiaca, mediocria, plana dein convexula, margine tenui pallidiore, demum depresso cincta; sporæ 8næ, incolores, polari-biloculares, ellipsoideæ, 0·013–0·02 × 0·0075–0·009 mm., paraphyses distinctæ, filiformes, supra 2–3-articulatæ et amplo-clavatæ. Gonidia flavescentia, diam. 0·009–0·02 mm. Corticola, Canterbury, New Zealand (*T. W. N. Beckett*).

Physcia laciniatula, Strn.

Thallus albidus vel pallido-albidus (K flavens), laciniosus laciniis sæpe margine adscendentibus, crenatis et servediosis, subtus pallidus, nigro-fibrillosus; medulla alba (K fl. C fl.); apothecia fusca vel fusco-nigra, plana, majuscula, leviter elevata, margine elevato folioso-coronato vel laciniato vel coralloideo-diviso cincta; sporæ 4–8næ fuscæ, 1-septatæ, sæpissime 2-nucleatæ, 0·03–0·042 × 0·014–0·02 mm. Supra muscos prope Illawarra, New South Wales (*Kirton*).

I cannot associate this with any other.

Physcia sublurida, Strn. Proc. Roy. Soc. Vict., 1880.

Thallus parvus pallidus vel virescenti-pallidus, demum pallide cervinus, adpressus, laciniatulus laciniis imbricatis multifidis, subtus pallidus et rhizinis pallidis munitus; medulla rufescens vel rubescens, K— C—; apothecia cæsio-pruinosa, margine pallido vel carneo, fere integro cincta; sporæ 8, ellipsoideæ, fuscæ, 1-septatæ, 0·014–0·018 × 0·0065–0·008mm. hypothecium incolor. Ad ramulos prope Brisbane (*F. M. Bailey*).

ART. XVI.—*An Inquiry into the Seedling Forms of New Zealand Phanerogams and their Development.*

By L. COCKAYNE.

[*Read before the Philosophical Institute of Canterbury, 1st November, 1899.*]

Plates VIII., IX.

PART III.*

WITH regard to the seedlings treated of in my former papers,† it is not worth while making any additions at present to what has been already published. This arises chiefly from the fact that most of the young plants are still growing in the pots where the seed was sown, and, now that spring has returned, the vigorous growth which it has induced, coupled with the moist, sheltered, warm environment of the greenhouse, has brought about in nearly every instance either a reversion to the already described juvenile form, or else that the latter still persists. Thus young *Carmichaelia* seedlings, which had commenced to develope leafless cladodes, are now putting out leafy shoots; even adult plants of *C. crassicaule,* both in greenhouse and shade-house, are rapidly producing stems well furnished with leaves, while on the other hand specimens in the open air present the usual half-dead looking appearance of the wild plant. Although a greenhouse in spring-time is not good for observing later seedling developments, it does not follow that it is unsuitable for investigating the earlier forms of growth; on the contrary, the conditions of growth there are not so very different from those afforded by nature, since in the natural habitat germination can only possibly take place during a period of wet, when the surface of the ground would remain moist for some time. Ganong writes regarding the *Cactaceæ*‡: "The germination of the seeds at home in the desert must take place in the rainy reason, for then only is the necessary water available. Now, the conditions of the desert in the cloudy time of the year are not so very different from those of our greenhouses."

To guard against error in the shape of getting seedlings wrongly labelled, I have this season adopted the

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* In my former paper, on page 382, line 9, the word *seed* occurs as a slip of the pen, *capsule* being, of course, the word intended. I usually sow Veronica-seed capsule and all, especially if the seed be gathered before it is quite ripe.

† Trans. N.Z. Inst., vol. xxxi., 1898, pp. 354–98.

‡ "Contributions to a Knowledge of the Morphology and Ecology of the Cactaceæ" (Annals of Botany, 1898, vol. xii., p. 428).

plan of putting a number on the pot itself, as well as a numbered label bearing the name of the plant.

Writing of *Coprosma acerosa* (*loc. cit.*, p. 386), I pointed out how the stipules with their glandular tips were most likely organs of protection for the young buds. At the time of writing this I was quite unaware that Cheeseman had already pointed out the same fact,* stating that, "At the apex of the very young stipule a gland is situated, which secretes a copious supply of a viscid mucilaginous fluid. These glands are highly developed and in an active state when the adjacent leaves are in the early stages of growth, but shrivel up and cease to secrete long before the leaves attain their full size."

Some of the most interesting of the seedlings described in this paper were raised by Mr. S. D. Barker, to whom I am much indebted for permission to use his rare and valuable material. To Mr. A. L. Taylor, of the Christchurch Botanic Garden, I must also express my obligation for having assisted me with seeds and seedlings. Finally, I beg to thank Mr. F. A. D. Cox, of Whangamarino, Chatham Islands, a most enthusiastic naturalist, whose assistance in procuring me Chatham Islands material and in giving information as to habitats of plants is simply invaluable.

Carmichaelia angustata, T. Kirk.

Only one seedling examined, and that about one year old, raised by Mr. S. D. Barker from seed sent by Mr. T. Kirk, F.L.S., and collected in the original habitat of the species. Germinated in about fourteen days (*Barker*). The plant was approaching its final form, but from the base of the main stem were young reversion shoots of the early seedling form.

Description of Seedling.

Early leaves (Plate VIII., fig. 1) simple, rotund, emarginate, bright-green, 7 mm. long × 8 mm. broad (exclusive of petiole); margins entire, reddish; midrib slender; veins 5, alternating; petioles 6 mm. long, semiterete, channelled above, articulated to midrib and to stem.

Later leaves ternate, with rotund-emarginate or obcordate leaflets, 4 mm. × 4 mm.

Lateral branch from older portion of plant (Plate VIII., fig. 2) spreading at right angles to main stem, wiry, deeply furrowed; edges of furrows translucent.

Older leaves ternate, distichous, inserted at regular intervals along branch, and becoming smaller towards its apex.

Leaflets 8·5 mm. long × 7·5 mm. broad (exclusive of petiole), obcordate, entire, glabrous, often more or less

* "On the New Zealand Species of *Coprosma*" (Trans. N.Z. Inst., vol. xix., 1887, p. [illegible]

cuneate at the base; midrib raised on under-surface of leaf, projecting beyond base of leaflet, slightly bent downwards, and articulating with petiole, thus raising the horizontal leaflets slightly above the petiole; terminal leaflet usually longest.

Other leaflets rather smaller than the earlier ones.

Stipules subulate, membranous, rarely rounded at apex.

This species is described in the Students' Flora, recently published (p. 114).* It is one of the leafy species, and seems to be very similar, judging from the description (p. 114), to *C. grandiflora*, the seedling form of which has not yet been described. Like nearly all the seedling *Carmichaelias* that I am acquainted with, it has entire, almost rotund, leaves at first. The mature leaves, according to Kirk, are deciduous.

Notospartium torulosum, T. Kirk.

Seedlings raised by Mr. S. D. Barker from seed collected in his garden from plant brought originally from Mount Peel. Germinated in about fourteen days (*Barker*).

Description of Seedling.

Early development: The hypocotyl reaches a length of 8 mm. before the pale-coloured cotyledons are released from the seed-coat, which still encloses their upper and apical halves. At this stage the cotyledons lie with their upper surfaces pressed close together. As development proceeds the hypocotyl, at first pale-coloured, tender, and semiprostrate, becomes green, woody, and erect, while the cotyledons gradually open out, increase in size, becoming finally 9 mm. long × 4 mm. broad; are fleshy, obovate-oblong, slightly falcate, glabrous, petiolate with very short petioles, which are connate at the base. While the cotyledons are slowly developing, the growing point of the stem emerges from between them, and rapidly developes the 1st internode, while at the same time the 1st leaf is being developed, which quickly becomes furnished with a petiole longer than the internode, the lamina at the same time growing very quickly, becoming 1 cm. in length, rotund in shape, with emarginate apex and surface semipatent. By this time the 2nd internode is lengthening, with a leaf being developed at its apex, having a short thick petiole, and the sides of the lamina pressed closely together and vertical. The 3rd internode is now very short, and is enclosed and protected by two triangular stipules, furnished at their apices with one or more hairs. At this early stage the leaf has a red margin, not to be seen so far in the more mature leaves. As the 2nd leaf developes, the

* "The Students' Flora of New Zealand," by Thomas Kirk, F.L.S., Wellington, 1899.

3rd internode grows considerably, until by the time that the leaf is developed it almost equals the 2nd internode, now 4 mm. long.

Seedling with cotyledons and three leaves (Plate VIII., fig. 3).

Stem flexuous, each internode being slightly bent from the preceding in an opposite direction, but ascending upwards, channelled, marked with a few scaly hairs, swollen at nodes.

Leaves (so far as developed) very uniform, almost rotund, patent, entire except for emarginate apex, glabrous, rather dull-green; under-surface more glaucous than upper, with raised midrib.

2nd leaf 11 mm. long × 6 mm. broad; petiole 4 mm. long, terete, articulated to lamina and to stem.

Stipules triangular, opposite, usually reddish with pale membranous margins.

The largest of the plants examined had a stout branch coming from the axil of each cotyledon, also a still shorter branch from the axil of the 1st leaf. The leaves on these and their development were similar to what has been described above.

Kirk (*l.c.*, p. 117) describes the leaves on seedling plant thus: "1-foliolate, obovate, emarginate, jointed to the petiole." The term "obovate" will certainly not apply to fully developed leaves, though it would suit well enough an immature leaf (see 3rd leaf in fig. 3). The South Nelson plant grows on grassy flats by the Mason River, in full sunshine, and also on the slopes of the Whale's Back in similar situations to ordinary tall-growing leafless *Carmichaelias*, in the full sunshine. The mature plant is quite leafless, and the branches are stiff, slender, and terete. Mr. S. D. Barker has plants from all the localities mentioned in the Students' Flora growing in his garden. The Mount Peel and Mason River plants look very similar, but the Waikare plant might very well be a different species. Its stem is flat, not terete. Under the stimulus of spring its young growth consists of reversion shoots, with flat stems and ternate small leaves, reduced sometimes to a single narrower leaflet (see fig. 3^1, Plate VIII.)*

Convolvulus erubescens, Sims.

Seedlings grown by Mr. S. D. Barker from seed collected from cultivated plant in his garden, originally from the Port Hills. Germination very rapid (*Barker*).

* Since writing the above description I have had an opportunity of further examining Mr. Barker's seedlings. The largest is 8·7 cm. tall, with ten branches, but still with entire leaves and quite terete, showing no sign of any such development as exhibited by the Waikare plant.

Description of Seedling.

The thick fleshy hypocotyl is developed rapidly, at first supine, then ascending with its upper portion. At the same time the radicle makes quick growth, in many instances lying on the surface of the ground for some time before the tip bends down into the soil. The cotyledons remain in the seed-coat absorbing the nutriment while hypocotyl and root thus develope (see Plate VIII., fig. 5). Here they are closely pressed together, with each lamina conduplicate. As the laminæ unfold the petioles lengthen, become erect, and the laminæ almost touch and are vertical; finally increasing greatly in size, they separate and become horizontal. In the meantime a slender stem has emerged from between the connate petioles, at first straight and erect, then as development proceeds twining slightly from right to left in its upper part, and becoming furnished with leaves at first opposite, but those later developed alternate.

Cotyledons 10·5 mm. long × 10·5 mm. broad (exclusive of petiole), oblong or rotund, emarginate or obcordate, soft, rather dull-green on upper but paler on under surface; margin entire, except at apex, tapering just at base into petiole, the margins here being slightly inclined upwards, and thus forming continuation of the channel of petiole; veins few, slightly sunken (Plate VIII., fig. 4).

Leaves alternate, obovate- or ovate-oblong, emarginate, truncate at base, with very long petiole; in other respects similar to the cotyledons.

Further development not yet seen.

No. 812. **Carmichaelia**, sp. Plate VIII., figs. 6, 7, 8, 9, 10.

The pod is 5 mm. long × 4 mm. broad, oblong, slightly swollen, 2·75 mm. thick; beak straight, stout, subulate, acute, 2 mm. long; seeds very light greenish-brown mottled with black spots, 2 usually, sometimes 3, in each pod. Seed collected from one plant with pinnate leaves not unlike *C. grandiflora*, growing in complete shade on moist rocks in the gorge of the River Waiau, near the bridge to Hanmer. Sown 7th June, 1899; germinated 23rd June, 1899—sixteen days.

Description of Seedling.

Fig. 6 shows the earliest stage of development observed, the hypocotyl and radicle being considerably developed before the cotyledons have emerged from the seed-coat. Fig. 7 shows a more advanced state of development, with ring of long hairs at crown of hypocotyl for fixing plant to soil, also a few minute hairs on the root. At this point the cotyledons show a faint sign of chlorophyll, and are issuing from the soil, but the hypocotyl is still underground and quite pale in colour.

Root straight, deeply descending, 9 cm. long on plant 2 cm. high.

Hypocotyl fleshy, thicker than stem.

Cotyledons obovate, sometimes falcate, thick, entire, glabrous, with short thick stout petioles connate at base.

1st leaf variable in size, from 6 mm. long × 6·5 mm. broad (excluding petiole) to 9 mm. long × 9 mm. broad, rotund or ovate-rotund, emarginate, sometimes with apiculus in sinus, rounded cuneate or truncate at base, with a few white bristly hairs especially on midrib and under-surface; midrib evident on under-surface of leaf, obscure on upper surface; petiole three-quarters the length of lamina, channelled above, articulated to midrib and stem.

2nd leaf similar to 1st; in many of the plants now about four months old not yet fully developed.

3rd and 4th leaves not yet nearly fully developed on most plants.

Colour of leaves: Some green throughout, except for purplish-brown margin; others dark purple-brown on upper surface; others dark-brown blotched with lighter brown.

Stems wiry, rather stout, terete, flexuous, upright or bending towards ground at first, channelled, swollen at nodes, sparsely hairy below, with few white bristles, which are much more abundant on growing-point and youngest leaves.

Stipules small, triangular, in axil of leaf.

The seedlings vary considerably in size and colour of leaves, some of which are very curiously variegated with large blotches of paler colour. Most of the leaves are of similar shape, but some are much more narrow, with a deep sinus at the apex (fig. 10). The rapid development of the root while the seed is yet within its seed-coat is of great importance to secure a sure water-supply in stony ground, and to fix the plant firmly by the time the wind can have an effect. In the plants examined the leaves are all bent sideways a little from the horizontal. This, perhaps, would not be so in a state of nature, and may be owing to their artificially grown position, and be simply heliotropic curvature.

Pseudopanax chathamica, T. Kirk. Plate IX., figs. 11, 12, 13, 14, 15, 23, 24.

Seedlings collected and sent alive by Mr. Cox from Chatham Islands.

Description of Seedling.

Hypocotyl pale in colour, shining, glabrous, terete, woody stout.

Cotyledons 1·15 cm. long × 6 mm., oblong, entire, persistent for a long time, rather thick and coriaceous; midrib usually obscure; petioles semierect, thick and rather coriaceous, channelled above, swollen and connate at base.

Leaves (1 and 2) alternate, ovate-lanceolate to obovate, usually tapering at base into petiole, entire for lower half, serrate for upper half; serrations regular or varying in depth and size; apex sometimes rounded, sometimes semitruncate, or, again, the upper half of the leaf is not fully developed, and looks as if bitten or torn across the middle, as in figs. 23 and 24, Plate IX.; midrib raised on both surfaces.

3rd leaf: Fig. 13 shows this in state of development; the toothing is very even and conspicuous, and shape linear-lanceolate, becoming quite lanceolate or obovate-lanceolate in the fully developed leaf.

Later leaves larger than the earlier ones, but still of same type, though narrower in proportion to their length; in young plant 8 cm. high not deflexed downwards, but the leaf-blades are horizontal and point slightly upwards, 10 cm. long × 4·5 cm. broad; in other plants narrower than this, and sometimes with upper half abortive; midrib very strong; veins distinct; petioles short, stout, erect, channelled above, swollen and articulated to stem at base.

Stem erect, terete, pale-coloured, rather shining, soon becoming naked through shedding of leaves, and so marked with leaf-scars.

The stage between the earlier seedling forms and the mature form I have not seen, but of this latter Mr. Cox has sent me a most complete set of fruiting specimens, showing also every form, I should take it, of mature leaf. These adult leaves do not vary to any very great extent from the later seedling ones as figured in figs. 11 and 15, and described above from older specimens; the main distinction is in length and width, they being much narrower in proportion to their length. Sometimes the leaf is almost entire, narrow lanceolate, with an acute apex; at other times the apex is truncate, and then toothed and cut in many ways; while, again, the upper third of the leaf may be undeveloped or abortive. To approach the difficult question as to why the early form of the Chatham Islands plant should differ so much from the closely allied varieties in New Zealand, and not go through the stage with tall upright stem and exceedingly long, narrow, deflexed leaves, would require a most intimate knowledge of the environment of this plant in the Chatham Islands, which could only be learnt by careful investigations on the spot.

The deflexed-leaf form of New Zealand is possibly an adaptation for pushing up to the light through more or less dense surrounding vegetation, spreading leaves under such circumstances of growth being a disadvantage. In the Chatham Islands the opposition from neighbouring plants may be less, and so the deflexed leaves would be no advantage to the plant; but all this is the merest surmise. It is worthy of

remark that the large-leaved seedling plant described above resembles very much in leaf-form the figure on pl. 38D, in Kirk's "Forest Flora," of *Pseudopanax crassifolia*, var. *unifoliata*, while in many instances the mature leaves of our plant are not unlike those of *P. crassifolia*, var. *trifoliata* (pl. 38C). The truncate form of leaf so common in the mature form of *P. chathamica* seems strongly hereditary, as evidenced by so many leaves being only partly developed, even amongst the early seedling leaves.

No. 851. **Carmichaelia enysii,** T. Kirk. Plate IX., figs. 16, 17, 18.

Seed collected by Mr. W. G. Rutherfurd in the neighbourhood of Kurow, Otago. Sown 1st September, 1899; germinated 6th September, 1899—five days.

Description of Seedling.

Early development: The cotyledons remain enclosed in the seed-coat while the hypocotyl and radicle develope to the extent shown in fig. 16, where the cotyledons have just emerged from their covering. The hypocotyl is white, and already exceedingly thick and succulent. The thick cotyledons as they open out become green and rapidly increase in size, while from between them a shoot emerges, which is at first quite terete, and having its growing-point protected by succulent ciliated stipules; as development proceeds it becomes much flattened above, and is furnished at the nodes with small stipules, from the axils of which rudimentary buds emerge. By the end of fifty-four days the state described above had been reached.

Hypocotyl 10 mm. long, mostly above ground, very pale-green, thick, fleshy, glabrous.

Cotyledons obovate- or oblong-spathulate, sometimes falcate, extremely succulent, thick and juicy, glabrous, shortly petiolate with petioles channelled on upper surface and connate at base.

Cladode 4·5 cm. long (in oldest specimen), 2·75 mm. broad in widest part, terete near base, green, much grooved, sparsely hairy with adpressed rather bristly white hairs, erect, slightly flexuous.

Stipules small, adpressed to and enclosing adjacent margin of cladode, broadly triangular, succulent especially when young, ciliated at margin and hairy on under-surface; hairs as on cladode.

Carmichaelia enysii is a very dwarf shrub found in the very driest portions of the lower mountain region of the South Island, and, according to Kirk, on the south-east side of Ruapehu, North Island. It grows on stony flats, old river-beds, river-terraces, and the like, forming large dense patches

rising to a height of from 3 cm. to 6 cm., or being even less in stature, and made up of stout creeping or partially ascending woody branches, bearing erect or semierect narrow cladodes 1·4 cm. in length or a little longer, and 1 mm. broad or even much less—according to Kirk (*loc. cit.*, p. 108) $\frac{1}{20}$ in. to $\frac{1}{12}$ in. broad—and usually quite leafless. "Leaves only found on very young plants, small, orbicular, emarginate, shortly petioled" (Kirk).

Unlike the other species of *Carmichaelia* of which I have treated up to the present, *C. enysii* does not go through an early leafy stage with a true stem and large orbicular leaves, to be succeeded by cladodes more or less leafy; on the contrary, it developes at once this semi-leafy form, which is succeeded finally by a much dwarfer and quite leafless growth. *Carmichaelia nana*, a closely related species, behaves in a similar manner. A seedling of this latter from seed sown on the 10th December, 1897 (No. 351), is now (October, 1899) furnished with one long sparsely leafy cladode 9 cm. in length, the leaves small and oblong-emarginate. Very young seedlings of *C. monroi*, another related species, are behaving in a similar manner, and developing erect cladodes with small obcordate leaflets. A plant of this latter species from Mount Isabel, Hanmer Plains, had when collected both the ordinary broad short leafless cladode and the tall narrow seedling form of growth. This seedling form, as exhibited in these three species, reminds one of the second stage of development of the tall leafless *Carmichaelias;* so much so indeed that it is hard to believe, when for the first time examining a pot of seedlings of *C. nana, e.g.*, that a mistake has not been made at the time of sowing, and that they are not seedlings of *C. flagelliformis* or of one of its allies. This resemblance between the first state of development of the dwarf *Carmichaelias* on the one hand and of the later and second stage of development of the tall *Carmichaelias* on the other hand, coupled with the fact that the former do not go through a first form with true stems and large leaves, seems to point out that the "*nana* section" are descended from tall leafless ancestors, just as these latter may have descended from the leafy *Carmichaelias*. Thus we may have already a clue to the phylogenetic development of the species of *Carmichaelia*, the leafy forms, such as *C. grandiflora*, which require a moist atmosphere, being probably the earliest, and the extremely xerophilous *C. monroi*, *C. nana*, and *C. enysii* forming the most recent link in the chain, with *C. flagelliformis* and its allies occupying a position midway. This seems the more likely since in *C. uniflora* there seems to be a connecting-link between *C. nana*, &c., and *C. flagelliformis*, &c., its final form looking like an arrested early seedling form of the "*nana* section" (fig. 18), while *C. flagelliformis*, &c.,

if grown in a moist atmosphere, will develope compound leaves, and in appearance approach *C. grandiflora*.

The rapid germination of the seeds of all the species of *Carmichaelia* is of interest, since it is only by very rapid germination that multiplication of the species by means of seeds would be possible, growing, as most do, in dry localities, where the ground could never remain wet, near and on the surface, for a sufficiently long period to permit a slow germination. In connection with this the length of time that many *Carmichaelias* retain their seeds in the pods on the plants, from the summer of one year to the spring of the next, gives a chance for some of the seeds to fall to the ground just at the season of the year—late winter and early spring—most suitable for their germination.

No. 700. **Discaria toumatou,** Raoul. Plate IX., figs. 19, 20, 21, 22.

Seed collected from one plant growing on sand-dunes in neighbourhood of New Brighton, Canterbury. Sown 18th January, 1899; germinated from 1st August until 2nd September, 1899.

Description of Seedling.

Early development: The cotyledons remain for a considerable time within the seed-coat absorbing nutriment, while the hypocotyl and root develope rapidly, together attaining a length of 42 mm. (fig. 19). At the same time the hypocotyl slowly grows upwards, rising arching out of the ground, the cotyledons still being subterranean, and with their upper surfaces closely pressed together. As the hypocotyl becomes stronger its elasticity overcomes the resistance of the soil, and the cotyledons are pulled out of the ground, enclosed or not as the case may be, in the seed-coat; next the aerial portion of the hypocotyl becomes erect, the cotyledons open out, and the leaves just become visible to the naked eye. As these increase in size the first internode lengthens rapidly, reaching by the time the 2nd pair of leaves are appearing a length of 10 mm. or more. The young leaves are conduplicate in the bud, and each with its juicy glandular stipules protects the enclosed younger leaves and growing-point of the shoot.

Seedling plant 4·3 cm. high, thirty days old, with cotyledons and two pairs of decussate leaves.

Hypocotyl (above ground) 10 mm. long, terete, glabrous, woody, pink on lower and green on upper half.

Cotyledons obovate-oblong, 8·25 mm. long × 5·5 mm. broad (at first 3·5 mm. × 2·25 mm.), succulent, pale-green, obscurely 5-nerved, entire, obtuse, petiolate with very short petioles, which are connate at base.

1st pair of leaves 9 mm. long × 4 mm. broad, with short

petioles, stained with red, connate and swollen at the base, and together with extreme base of lamina parallel to and sheathing the stem; lamina ovate-lanceolate or oblong-lanceolate, bright glossy green, glabrous on upper but with numerous minute white scales on under-surface, quite entire usually for lower two-thirds of margin, sparsely toothed and usually stained with deep red on upper third; teeth in an early state of development glandular; apex sharply acute, midrib prominent on under-surface, but together with the usually 6 lateral nerves indistinct on upper surface.

2nd pair of leaves similar in all respects to 1st pair, except not yet quite as large.

Stem erect, terete, green, having numerous small white scales, swollen at nodes; 1st internode 1·8 cm. long; 2nd internode almost as long as 1st. In one plant, which had the upper portion of the stem removed two weeks ago, two opposite branches are developed from the axil of the cotyledons 4 mm. in length, and each with 2 leaves 2·75 mm. long.

Stipules 2, inserted at base of sheathing petiole, and united by their contiguous internal margins for half of their length or more; slightly longer than petiole; in very early state of development more than half size of leaf; free portion deltoid, ending in a mucronate gland, which shrivels as plant developes.

The petiole of the leaf just above its base has a hollow which receives the young bud, which is protected on either side also by the stipules.

Further development not yet seen.

Discaria toumatou of the sand-dunes is a low-growing shrub, with spreading, flexible, slender branches, usually leafless for the greater part of the year, but furnished at intervals of about 2 cm. with decussate, reduced, spiny shoots, 3 cm. in length, quite green, and which function as leaves. From beneath the axil of these, but from the axil of a fallen leaf, in spring, numerous leafy shoots, either much reduced through imperfect development of the internodes or well-developed reversion shoots with long internodes, are developed; the former bear flowers, and are finally cast off, the latter do not bear flowers the first season, but become permanent branches. These reversion shoots are similar to the early juvenile form described above, except that they have reduced shoots terminating in a spinous point issuing from the axils of the leaves. In an early stage of development these spines are almost entirely enclosed by two stipules, but, their lower portion growing very much more rapidly than the apical portion, the stipules are carried forward, and finally surround the base of the actual pungent point, which, at first quite soft, becomes extremely hard and sharp through its tissues completely drying up. The adult leaves (fig. 21) are narrower, longer, and with

much longer petioles than the juvenile; otherwise they are of the same type.

This behaviour of *Discaria*, to be in the early juvenile stage a leafy thornless plant, while the adult is leafless with assimilating spiny branches, reverting in spring to the leafy form, is almost identical with that of *Colletia cruciata*, another of the *Rhamnaceæ*, whose reversion shoots have been described and figured by Goebel.*

This or a closely allied plant, received under the name of *C. horrida*, I have raised from seed. Its early form is quite spineless, with lanceolate leaves 7 mm. long × 3 mm. broad, acute, and with three prominent teeth on each margin. As the plant grew these leaves were succeeded by sharp, spiny shoots, terete, and 9 mm. in length.

The quick development of the root of *Discaria* before its cotyledons issue into the air must be of great advantage to fix the plant firmly in an unstable medium such as sand, exposed as it is to constant winds.

EXPLANATION OF PLATES VIII., IX.

Plate VIII.

Fig. 1. Young growth from base of seedling plant, one year old, of *Carmichaelia angustata*.
Fig. 2. Lateral branch from same plant as in fig. 1.
Fig. 3. Seedling plant of *Notospartium torulosum*, Mount Peel variety.
Fig. 3^1. Reversion shoot of *Notospartium torulosum*, Waikare variety.
Fig. 4. Seedling plant of *Convolvulus erubescens*.
Fig. 5. Early development of seedling of *C. erubescens*—(*a*) hypocotyl, (*b*) radicle.
Fig. 6. Early development of *Carmichaelia*, sp., from Waiau Gorge.
Fig. 7. Later stage in the development of the plant shown in fig. 6.
Fig. 8. Still later stage of development of plant shown in figs. 6 and 7.
Fig. 9. Usual form of early leaf of *Carmichaelia*, sp., Waiau Gorge.
Fig. 10. Occasional leaf-form of seedling of *Carmichaelia*, sp., Waiau Gorge.

Plate IX.

Fig. 11. 2nd or 3rd seedling leaf of *Pseudopanax chathamica*.
Fig. 12. Seedling plant of *P. chathamica*, showing cotyledons and 1st leaf.
Fig. 13. Early stage in development of 3rd leaf of *P. chathamica*.
Fig. 14. Apical extremity of leaf shown in fig. 13.
Fig. 15. Leaf from older seedling of *P. chathamica*.
Fig. 16. Early stage in development of seedling of *Carmichaelia enysii*.
Fig. 17. Later stage of development of *C. enysii* than shown in fig. 16.
Fig. 18. Branch of *Carmichaelia uniflora*.
Fig. 19. Early development of seedling form of *Discaria toumatou*.
Fig. 20. Later stage in development of *D. toumatou* than shown in fig. 19.
Fig. 21. Adult leaf of *D. toumatou*.
Fig. 22. Early seedling leaf of *D. toumatou*.
Figs. 23, 24. Truncate seedling leaves of *Pseudopanax chathamica*.

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* "Pflanzenbiologische Schilderungen," teil i., Marburg, 1889, pp. 17 and 18.

ART. XVII.—*A Sketch of the Plant Geography of the Waimakariri River Basin, considered chiefly from an Œcological Point of View.*

By L. COCKAYNE.

[*Read before the Philosophical Institute of Canterbury, 2nd August, 1899.*

Plates X.–XIII.

PART I.: INTRODUCTION.

REGARDING New Zealand plant geography, nearly the whole that has appeared up to the present time, especially in the "Transactions of the New Zealand Institute," has been of a floristic character. This, although of great importance to science in general, and of especial interest, moreover, to New Zealand botanists, does not meet the present-day demand by biologists for more minute details regarding the environment of plants and the adaptations to such that they have assumed. Scattered through the writings just referred to are here and there facts incidentally mentioned which bear on my subject. Sir James Hector, in 1869,* selecting a portion of Otago, arranged the plants into zones, determined by altitude, and divided these into subdivisions according to the prevalence of certain plants. He also illustrated the paper by means of an excellent sectional map, showing at a glance the nature of the plant-covering in that part of New Zealand.

Haast,† in 1864, pointed out the important fact that the climate of central Canterbury was of a continental rather than of an insular character. Various authors have divided the plants into communities, of which those adopted from Watson‡ are not to be commended—littoral, rupestral, and the like; indeed, when we examine the meaning of these terms as given by Kirk§ it can readily be seen that from an œcological point of view they have little value. Thus, littoral plants are described as those of the seashore, whether growing on sandy or muddy beaches, in salt meadows, or on sea-cliffs—stations truly which may offer very different life-conditions. Certain papers, such as on the naturalised plants of Port Nicholson,‖ on the fertilisation of plants,¶ on the dis-

* "On the Geographical Botany of New Zealand," by Sir James Hector (Trans. N.Z. Inst., vol. i.).

† Report of the Geological Survey of the Province of Canterbury, Christchurch, 1864, p. 23.

‡ "Topographical Botany," 1883.

§ "On the Botany of the Thames Goldfield" (Trans. N.Z. Inst., vol. ii., p. 89).

‖ T. Kirk, Trans. N.Z. Inst., vol. x., p. 362.

¶ G. M. Thomson, Trans. N.Z. Inst., vol. xiii., p. 291.

placement of native by introduced plants,* and others to be referred to later on, are of great œcological interest. But of all works on New Zealand vegetation the one which most concerns us here is that of Diels, entitled "Vegetations-Biologie von Neu-Seeland," which appeared originally in Engler's Botan. Jahrbuch for 1896. Although the author had never set foot in New Zealand, yet, with the aid of a considerable number of herbarium specimens, and of whatever literature was available, he wrote an œcological account of the vegetation of New Zealand and its adjacent islands. He also touched at some length on the origin of the component parts of the flora. Part of the data concerning the plants of the montane, subalpine, and alpine regions was, in response to a request from Dr. A. Engler, furnished by me. Now, since some of my statements may not have been altogether correct, I may be allowed for my own credit's sake to explain that I distinctly stated in a letter to Mr. Diels that I could not guarantee their scientific accuracy, since they were written from memory for the most part, and not from observations taken note-book in hand from the plants in their habitats. Nor had I any idea of the scope of the proposed work, or I might have been more cautious still. Be that as it may, the work appeared, and, when the conditions under which it was written are considered, it is indeed a work of no small merit. That it should contain errors goes without saying; the only marvel is that it does not contain many more. At any rate, it marks a distinct epoch in New Zealand botany, and now it remains for local botanists to supersede it with something more full and more accurate. To fulfil this want in some small measure will be attempted in this present work.

That a field botanist in a distant colony can endeavour to solve any of the very difficult problems which plant œcology presents is hardly to be expected. The very fact of being at active work in the field hinders the close study necessary before approaching and while engaged in such work; also, the almost entire lack of recent literature makes critical work quite out of the question. These higher problems—*e.g.*, the verifying or disproving hypotheses by accurate physiological experiments; the collecting multitudes of facts from the records of many writers; considering such, and deducing conclusions therefrom; or the examining material collected from all over the world to establish some point—such work and the like can only be attempted by men of great natural ability, special knowledge, and vast learning, with the most modern appliances to hand, and access to the literature of any particular subject. But such specialists, at home in their labora-

* T. Kirk, "The Displacement of Species in New Zealand" (Trans. N.Z. Inst., vol. xxviii., p. 1).

tories, cannot observe for themselves the actual environment of a plant in a distant land, or the manifold details connected with its life-conditions and the responding adaptations of the organism to these. Such can only be learnt by studying the plants in nature, and at all seasons. Experiments also with living plants can be more easily carried out at home than abroad, where, in many instances, it is very difficult to keep them alive, and still more so to grow them in a natural manner. This latter branch will form some small part of my subject, but the former—viz., the environment of the wild plants and their more evident adaptations—will constitute the greater part of what is to follow, so that the work as a whole will savour more of the open air than of the botanical laboratory or the study.

I have selected a small portion of the South Island for treatment rather than the Island in its entirety, since the time is hardly ripe for a work of such an extensive nature, and a smaller area can be treated much more thoroughly, and yet at the same time be eminently typical of the whole Island. Of all regions to be found in this Island none seems to offer itself as better or even as well suited for such an investigation as that under consideration. For, in the first place, a portion at any rate of the mountain region is easily examined, thanks to a coach-road, an excellent coach service, and the accommodation offered by two hotels. Other parts, too—the Canterbury Plains, the coastal region, and most of the foothills—are easy to examine. Also, it is the only region where meteorological records at so high an elevation as 641 m. have been kept, and which, in combination with those of Hokitika, afford some idea of the heavy western rainfall. On the other hand, the records of Christchurch and Lincoln tell us something of the weather of the Canterbury Plains and of the sand-dune region. The district also presents an admirable example of two distinct climatic regions, the one extremely wet, the other dry. There are also lower mountain, subalpine, and alpine zones, and many very characteristic plant-formations depending upon peculiarities of soil.

From what is written above it must not be imagined that the district as a whole is easy of access. On the contrary, a considerable portion is quite uninhabited. The valley of the River Poulter, for a distance of thirty miles or more, does not contain an inhabitant or even a hut, and the main sources of the Waimakariri, as also most of the country to the north of that river, is practically uninhabited. The mountains also in that part of the district being forest-clad up to a height of from some 900 m. to 1,200 m. makes the approach to the subalpine and alpine regions difficult. One trouble in the way of exploring such country is the taking of a sufficient food-supply to meet the danger of being cut off from the settled regions

by floods, for, since the stony river-beds are the sole roads, such an occurrence is by no means unlikely. I have especially called attention to these details as an excuse for the very imperfect examination that I have made of many parts of the district. One has often to leave interesting ground through bad weather, or this same weather may put a stop to all work. But if some of the region is uninhabited, this is all the more interesting to the botanist, since it has led to many places being still unused as pasturage for sheep, and where, in consequence, the original plant-covering of the soil remains undisturbed. Good examples of this occur at Walker's Pass, Goat Pass, the sources of the Poulter, and many places near the main sources of the Waimakariri. Mount Hikurangi, in the North Island, is also in the same condition, according to Mr. James Adams, who writes:* "Neither cow, nor horse, nor sheep, nor pig has ever desecrated the summit of the mountain, or disturbed there the designs of nature in the manner of the growth of plants."

All the observations recorded in this and to be recorded in the succeeding papers have been made by myself, unless the contrary be distinctly stated; they are the results of many botanical excursions taken during the past twelve years; also I reside and have an experimental garden† in the coastal region, situated partially on the older sand-dunes.

Regarding the photographs taken and to be taken of the various plant-formations, &c., I propose to place a set, numbered in accordance with the references in this work, in the Museum at Christchurch, New Zealand, since only a limited number can be published; and also dried specimens of all special forms of plants treated of.

For the identification of species I am in the main responsible; other identifications will be specially noted. Of course, in a flora not yet thoroughly understood errors of identification must occur; others will creep in through the necessarily rapid examination of many localities; both these sources of error are at the present time unavoidable, but I hope they will be minimised by the deposition of doubtful specimens in the museum, as stated above.

There are also in the New Zealand as in all floras a very considerable number of plant forms which some botanists consider as good and others as bad species. Now, it is essential for œcological work that every form treated of shall have a name of some kind, whether specific or varietal matters little. In many instances the structure of certain organs of a plant —for example, the leaves of a so-called variety which reproduces itself "true" from seed—differs altogether from that

* "On the Botany of Hikurangi Mountain," by James Adams, B.A. (Trans. N.Z. Inst., vol. xxx., 1898, p. 416).

† This will be referred to as "Tarata Garden."

of the type species to which it is referred. Other species vary simply through environment, and when such varieties are grown side by side under the same conditions they become indistinguishable. In such cases œcology can assist systematic work and check its results. Of late, botanists in New Zealand have been much more ready than formerly to admit closely related forms as good species, which certainly seems a step in the right direction.*

Only the angiosperms, gymnosperms, and pteridophytes are here treated of. With these, many lower plants are, of course, associated in the plant-formations as component and often most important constituents, but an account of these can only be undertaken by specialists.

The country to be treated of includes all the land drained by the River Waimakariri and its tributaries, with the exception of those portions of Big Ben and the Malvern Hills which form a part of its river-basin.

To the following I beg to express my most hearty thanks: Mr. D. Petrie, M.A., to whose splendid collection of Otago plants I have had full access; Professors A. F. P. Schimper, K. Goebel, and A. Dendy, for assistance regarding literature; Captain F. W. Hutton, F.R.S., who most kindly corrected the geological details; Sir James Hector, F.R.S., and Sir John Hall, K.C.M.G., for assistance regarding meteorology; Messrs. T. W. Adams, John Deans, W. Cloudesley, J. Rountree, S. Weetman, E. G. Staveley, manager of the Loan and Mercantile Company, A. L. Taylor, of the Christchurch Botanic Garden, and Mr. T. Douglas, manager of Mount White Station, who have rendered me much valuable aid.

Topography.

With regard to the main features of the region under consideration, we may make a primary distinction into lowland, table-land, and mountain regions.

Commencing with the lowland region, we find, near the mouth of the river, extensive sand-dunes, which terminate at the wide brackish lagoon formed by the river as it empties itself into the sea. Formerly the river also flowed into the sea more to the south, one channel, at any rate, going down the present bed of the Avon.†

The sand-dunes consist of two varieties—the recent, which are in a very unstable condition, constantly moved by the frequent high winds, and having the yellow-leaved *Desmoschœnus spiralis* as the leading plant; and the older, which are

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* As to what is meant by the term "species," Romanes has written at considerable length: see "Darwin and after Darwin," vol. ii., London, 1895, chapters viii. and ix., especially pp. 202–208 and 229–235.

† See map facing p. 396, in Haast's "Geology of Canterbury and Westland," Christchurch, 1879.

stable for the most part, and bear in consequence a more abundant vegetation than the first named.

Passing in a westerly direction from the dunes, the Canterbury Plain is entered upon, through which the river flows in a fairly straight course over a wide stony bed, margined occasionally with wet ground, in which situations *Arundo conspicua*, *Phormium tenax*, and often *Cordyline australis* are plentiful, and become a pleasing feature in the landscape. On the shingly river-bed, in its firmer portions, various species of *Raoulia* flourish, forming large silvery, moss-like patches. On either side of the river are stretches of often extremely stony ground, looking in some places almost as if it had been paved, and having for a plant-covering a low-growing and very characteristic vegetation, amongst which the dwarf, leafless, shrubby *Carmichaelia nana* is conspicuous. Interspersed with, and of much greater extent than, this stony ground are larger or smaller tracts of land suitable for cultivation, and varying from very light sandy and stony soil to rich dark-coloured loam of very great depth, the whole forming, indeed, one of the finest farming districts in New Zealand. The richest part of this land was for the most part originally swamp, occupied by *Phormium*, but such is now almost altogether reclaimed, and yields immense crops of cereals, potatoes, and the like, especially if the season be not too wet. These swamps and their immediate vicinity were most likely at an earlier date occupied by forests. This subject will receive further consideration when the pine forest plant-formation is treated of; here it need only be mentioned that a small portion of the primeval forest still remains in very fair preservation, having been well cared for by its owner, Mr. John Deans, of Riccarton, and affording a most valuable record of the former arboreal vegetation.

At about fifteen miles from the sea, in the neighbourhood of Courtney, some interesting low sandhills, mounds, or ridges are met with, having *Isolepis nodosa* on the sunny and *Phormium tenax* on the south-west side, with *Sophora prostrata* near their bases.

From the sea to the mountains the plains rise gradually at an average of 10·9 m. per mile, until at near the base of the latter—Mount Torlesse—they reach a height of 450 m. (For full particulars as to the fall of the Canterbury Plains, see Haast, *loc. cit.*, p. 403.)

At a distance of at from six to seven miles from where the river leaves the plain occurs the lower gorge; here the river has cut for itself a passage right through an isolated hill—Gorge Hill—standing towards the middle of that part of the plain, a most remarkable phenomenon when we consider that the river appears to have had the whole of the plain at its disposal for a bed. An account and probable explana-

tion of this is given by Captain Hutton* in a paper entitled "On the Lower Gorge of the Waimakariri." For our purposes the chief interest lies in the fact of a station for plant-life so different from the uniformity of the plain being provided by the rocky walls of this gorge, and where, indeed, quite a different vegetation is encountered. Amongst the plants found there are a number which, so far as I know, rarely occur at any distance from the sea, and this seems to strongly favour Captain Hutton's theory, the crucial point of which is that the sea at one time came up to this spot. Of these plants *Linum monogynum*, *Parsonsia rosea*, *Chenopodium triandrum*, and *Angelica geniculata*† may be especially cited. Regarding this latter Kirk writes,‡ "I have never seen this plant far from the sea, and doubt its occurrence inland."

Passing through a deep rock-bound gorge between the Torlesse and Puketeraki Ranges, six miles in length, according to Haast (*loc. cit.*, p. 244), the table-land is entered. On both sides of this gorge—the upper gorge—hills of some considerable size arise, covered with mixed forest in places, having *Fagus solandri* as its leading tree. This portion of the river has hitherto been most difficult to examine, but quite recently a road has been made for railway purposes, so the gorge on its south side is now easily reached. It is to be feared that this railway-construction will lead to the destruction of much of the vegetation, since already several fires have destroyed large areas of forest.

The upper plains of the Waimakariri form an extensive table-land, in which the bed of the river itself occupies, of course, the lowest part. The average height of the whole is, according to Haast, 630 m. (*loc. cit.*, p. 214), and the extent sixteen miles long by eleven miles wide. From its centre rise several high peaks, which are quite isolated — Mount St. Bernard, Mount Sugar-loaf, and Broken Hill. It is drained by various tributaries of the main river, which have cut for themselves deep beds and formed many extensive river-terraces, which afford in places a station for an interesting plant-formation of xerophilous shrubs, of which *Veronica cupressoides*§ is one of the most remarkable. The table-land is surrounded on all sides by lofty mountains, which are cleft by the Waimakariri and its tributaries, whose river-beds lead right into their fastnesses, so enabling the distant summits

* Trans. N.Z. Inst., vol. xvi., p. 449.

† I have not observed any of these species growing in the upper gorge. Mr. T. W. Adams tells me that *L. monogynum* was formerly common in the river-bed of the Hawkins, at 183 m. above sea-level.

‡ "The Students' Flora of New Zealand," Wellington, 1899.

§ Henslow, "Origin of Plant Structures," London, 1895, p. 108, speaks of this shrub as growing at great elevations on the mountains, whereas it is essentially a plant of the lower mountain and lower sub-alpine regions, growing on river-terraces.

to be reached, which but for such natural roads would be very inaccessible. To the northward are Esk Head, the Candlesticks, and the Snow-cap Range, giving rise to, proceeding from east to west, the Rivers Esk, Poulter, and Hawdon; to the eastward is the Puketeraki Range; to the southward the Mount Torlesse Range; to the westward the Craigieburn Mountains, giving rise to the Broken River and its tributaries.

Leaving the table-land and going in a westerly direction, the upper valley of the Waimakariri, twenty-two miles in length, is entered, its bottom occupied almost entirely by the wide stony bed of the river, and with mountains rising steeply on either side. On the north is a portion of the Dividing-range, giving rise to the River Bealey, River Crow, and the north branch of the River Waimakariri; on the south is the Black Range, giving rise to Bruce's Creek, Broad Creek, and several other unnamed creeks. At its western extremity the valley narrows, and turns quite suddenly to the south, soon rising above the forest-line. Here it is traversed by the main branch of the Waimakariri, the White River, which rises in a large glacier situated at the head of the valley. This valley is three or four miles long; the mountains are steep and rugged, and the river a foaming torrent.

In height the mountains vary from about 2,400 m. to 1,350 m., Mounts Rolleston, Armstrong, Davie, and Greenlaw in the Dividing-range, Mounts Franklin, Hunt, and McCrae in the Snow-cap Range, Mount Enys in the Craigieburn Mountains, and the main peaks of Mount Torlesse, Mount Binser, and the Puketeraki Mountains, being among the most lofty.

Unlike the Westland rivers, those of the Waimakariri rarely become impassable gorges. It is usually fairly easy to follow them from mouth to source. The Dry Creek from Mount Torlesse, the Broken River, River Esk, and River Poulter in the table-land, the Craigieburn River, Andrew's Creek, and the River Minchin, above Lake Minchin, present exceptions, but in no instance, the last-named river excepted, do we find anything approaching the Otira Gorge, to quote a familiar example.

Geology.

The mountains both of the eastern and western plant-regions belong geologically to Haast's "Mount Torlesse Formation," which contains rocks of various ages, from the Carboniferous to the Lower Jurassic (*loc. cit.*, pp. 266–280), consisting of sandstones, slates, and shales of various kinds. These sandstones are most easily split by the weather, and such excessive weathering, more particularly in the eastern region, has given rise to *débris*-fields, locally called shingle-slips, of very great dimensions, whose appearance, &c., will be

described more fully when treating of their very peculiar and amazing plants.

The surface of the table-land consists of fluviatile and glacial deposits, covered often with a very scanty alluvial soil, below the general level of which the rivers meander in several streams over wide stony beds, with huge terraces, sometimes four in number, on either side.

The Trelissick basin has been examined in a thorough manner by Captain Hutton,* and so the relation between the soil and its plant-covering can be there better studied than in any other part of the district. The sections shown in pl. xxv. are of great importance for this purpose. The Trelissick basin consists of undulating country, rising in places to a height of 900 m., and formed of rocks belonging to—the Pareora system (Miocene), a series of blue clays, shales, and sandstones; the Oamaru system (Oligocene), consisting of coralline limestone, underlain by volcanic grits and tuffs; the Waipara system (Cretaceous), formed of argillaceous limestone and calcareous sandstone underlain by marl. In addition to these are to be found some brown-coal beds towards the northern extremity of Mount Torlesse, at the base of the Craigieburn Mountains, in the Craigieburn Creek, and elsewhere. In the Esk Valley there is also a small tract of limestone country, which is described by Haast (*loc. cit.*, p. 151) as consisting of "younger outliers of greensand and calcareous limestone, which have been broken through and covered with dolerites, to the hard nature of which they doubtless owe their preservation during the great Ice age."

Leaving the mountain region and coming to the Canterbury Plain, it is seen to be formed of stony *débris* brought down by the rivers from the neighbouring mountains. Its flat monotony is slightly relieved at its upper end by several low hills named respectively Racecourse Hill, Little Racecourse Hill, Gorge Hill, View Hill, and Burnt Hill. Of these the two latter owe their importance to the fact of the rocks consisting of basalt and dolerites; Gorge Hill belongs, on the other hand, to the Mount Torlesse formation, already mentioned; while Racecourse and Little Racecourse Hills consist of shingle.

At about four miles from the sea the sand-dunes are encountered—at first ancient dunes, which are separated from the more recent by stretches of low-lying swampy land. These sandhills are formed by the sand blowing inland from the seashore during the frequent and persistent east winds, while the heavy north-west and south-west (if dry) gales blow back again to the shore large quantities of sand, often changing more or less the aspect of the scene.

* Trans. N.Z. Inst., vol. xix., p. 415.

Meteorology.

I have purposely kept back the publication of a number of details shown in the various meteorological tables, which have been issued from time to time by the Colonial Museum and Survey Department under the direction of Sir James Hector, F.R.S., until treating specifically of the plant-formations of each region. Of these tables we need only consider those of Hokitika, Bealey, Christchurch, and Lincoln. These are, of course, so far as they go, of considerable value for a consideration of the effect of the climate of those stations on the plants in their immediate vicinity. Hokitika, however, is not in the district under consideration, and its statistics are only quoted so that some inference can be drawn therefrom as to the rainfall on the dividing-range. Lincoln also is not in this district, and, although only a few miles distant from Christchurch, it has, as pointed out by Mr. Méeson,* a rainfall of 2 in. or 3 in. greater than the latter locality. As for Christchurch, observations taken in a town, with shelter from houses and smoke, do not give any good criterion from which to estimate the temperature of the surrounding country. The details from Bealey, on account of its almost subalpine situation, at no great distance from glaciers of considerable size, receiving as it does a large portion, at any rate, of the great western rainfall, are by far the most valuable for plant œcology.

From the above considerations it is abundantly evident that our data as to the climate of the region under consideration are not very satisfactory. According to Schimper† there should be given for each month of the year the mean maximum and the mean minimum temperature, the rainfall and the number of rainy days, the mean maximum amount of moisture in the air and the mean minimum, the hours of sunshine, the force of the wind, and the evaporation. But should the meteorological records of any station be of the greatest accuracy and voluminousness, they would only furnish a most general idea of the climatic influences to which a plant is subjected. The side of a gully without sunshine at all during winter—to quote an extreme but quite common case — which even in midsummer receives but a scanty supply compared with the opposite side, and which during the slight frosts of early April remains frozen hard all day, presents an altogether different plant-station to the sunny side. Particular instances of this will be cited, and the differences in vegetation presented by two such sides will be seen to be quite remarkable.

* "On the Rainfall of New Zealand," Trans. N.Z. Inst., vol. xxiii., p. 546.

† "Pflanzen-Geographie auf Physiologische Grundlage," Jena, 1898, p. 190.

The length of time which the snow lies on the ground and its depth, the shelter or exposure experienced by plants, earth and water temperatures, amount of radiation from differently coloured soils or leaves, these and many more particulars which could be suggested are not to be learned from existing meteorological reports, which treat, of course, only of strictly atmospheric phenomena. My own notes furnish a few details on some of these or similar matters, and will be quoted in due course, but they are, unfortunately, both meagre and disconnected. Notwithstanding what has been said above, the New Zealand meteorological reports furnish us with some valuable information, much of which is given in an admirable condensed form by Sir J. Hector.*

Firstly, as to Rainfall.—The average yearly rainfall from 1864 to 1893 inclusive is—Christchurch, 25·10 in.; Hokitika, 119·91 in. The greatest rainfall for any part of the Waimakariri district which I can find recorded is Bealey, 1878, 155·891 in. in 207 days, while Hokitika for the same year registered 154·446 in. in 259 days, and Christchurch during that year the lowest recorded up till 1893—viz., 13·540 in. in 104 days. Taking Lincoln for the years 1890, 1891, 1892, 1893, the rainfall and the number of days on which rain fell was—14·836 in., 104 days; 20·575 in., 98 days; 27·883 in., 124 days; 22·05 in., 115 days. At Bealey, for the eleven years previous to 1879, the rainfall and rainy days was 103·767 in., 174 days; at Hokitika during the thirteen years previous to 1879 it was 119·047 in., 193 days; and at Christchurch during the fifteen years previous to 1879 it was 24·907 in., 117 days. The following extract from Hector's paper (*loc. cit.*, p. 428) is of interest:—

REVIEW of the PROPORTIONS of RAIN in NEW ZEALAND.—Percentage of Rainfall for Winter, Spring, Summer, and Autumn respectively.

Hokitika	24	28	28	20
Bealey	22	28	31	18
Christchurch	31	21	25	23

From the above statistics it may be seen that there falls nearly five times as much rain on the western side of that part of the Island under consideration as falls on the eastern, and that Bealey is well within the region of the western rains. There are also almost twice as many days on which rain falls at Hokitika as at Christchurch, while, if the average amount of rain be considered which must fall upon each of these days, the difference as to climate will appear still more marked.

The proportions of rain as quoted for each season show a remarkable equality, still it is plainly evident that the driest

* "Climate, Temperature, and Rainfall," New Zealand Official Yearbook, 1894, p. 423.

seasons in the west are—(1) Autumn; (2) winter; while spring and summer are almost equally wet. On the east winter is considerably the wettest season, and the remainder are much alike, spring and then autumn being a little drier than summer. Taking the months (*loc. cit.*, p. 428), on the east (Christchurch) the driest is September, 1·161 in., and the wettest June and July, 3·189 in. and 2·449 in. respectively; and on the west (Bealey) the driest month is March, 3·921 in., and the wettest is October, 15·501 in., closely followed by December, 14·087 in., a considerable contrast to the same month (1·622 in.) in the east.

Secondly, as to Temperature.—The average yearly maximum temperature for Christchurch is 88·16° Fahr., the average minimum 25·16° Fahr.; and for Bealey 78·08° Fahr., and 12·38° Fahr. The average temperatures at Bealey are—Winter, 37·40° Fahr.; spring, 46·04° Fahr.; summer, 54·86° Fahr.; autumn, 48·56° Fahr.; for the year, 46·76° Fahr.: and at Christchurch they are—Winter, 43·52° Fahr.; spring, 53·24° Fahr.; summer, 61·52° Fahr.; autumn, 53·60° Fahr.; for the year, 52·88° Fahr. The average daily range of temperature is of interest; unfortunately, I can only quote that of Christchurch:—

	Deg. (Fahr.).		Deg. (Fahr.).
January ..	18·36	July	16·56
February ..	16·56	August ..	16·02
March ..	17·46	September ..	16·20
April	17·10	October ..	18·54
May	16·38	November ..	19·08
June	14 94	December ..	17·10

Read in conjunction with the above the following mean monthly temperatures at the same station for the years preceding 1877 are important, though the maximum and minimum temperatures for the same period would be more valuable:—

	Deg. (Fahr.).		Deg. (Fahr.).
January	62·1	July ..	42·7
February	61·2	August	44·0
March	58·0	September	48·6
April ..	53·9	October	53·1
May ..	47·8	November	56·9
June ..	43·3	December	62·2

At Bealey during the same period the averages were:

	Deg. (Fahr.).		Deg. (Fahr.).
January	56·7	July ..	35·8
February	56·3	August	37·1
March	53·8	September	41·6
April ..	48·6	October	46·0
May ..	42·6	November	50·4
June ..	37·1	December	54·9

The following table shows the maximum and minimum temperatures at Bealey for a course of years:—

Year.		Jan.		Feb		March.		April.		May.		June.		July.		August.		Sept.		Oct.		Nov.		Dec.	
		Max.	Min	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max	Min.	Max.	Min.
1871	..	79 2	..	75·7	..	72·6	..	62	..	58	..	53 8	4·4	53·5	..	53	..	63	..	68	..	73·5	..	73	..
1872	..	82	..	74	..	74	..	73	..	59	26	55	12	52	13·8	49	14·4	60	22	64	24	77	30·5	78	36
1873	..	79	34	80·5	36	84	35·5	68	26	58	25	56	16·6	48	20	53	20	56	27·3	72	14·8	69	30·6	78	37
1874	..	81	33	84	31	73	32	64	27	57	23	52	7 6	50	23·7	53	21·4	54	24	65	28	79	30	74	31
1875	..	82	38·4	74	40	70	29·4	68	29	58·5	26	58·8	18	52	19	50	20	57	25	69	26	69	31	84	39
1876	..	81	34	83	36	74	31	69	28	64	22	51	4 8	47·6	16	50	29	55	26	72	30	78	33	77	39

This may be compared with the temperatures of the coastal region as shown in the following table, giving the maximum and minimum temperatures at Christchurch for the same series of years :—

Year.		Jan.		Feb.		March.		April.		May.		June.		July		August		Sept.		Oct.		Nov		Dec.	
		Max	Min	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1871	..	86·9	..	76·8	..	82·4	..	71	..	74·1	..	53·1	24·9	65·1	..	64·5	..	65·5	..	72·4	..	78·8	..	82·3	..
1872	..	95·7	..	94·1	..	81·8	..	72·2	..	68·5	32	64·9	21·5	58·6	27 5	58·2	23 7	74·2	30·2	74·1	30·3	86·8	39 9	92·3	41·8
1873	..	85·8	42·2	75 3	43 4	80 3	41·4	63·2	30 6	68	29 8	68·2	25 8	55	28·3	66	27·5	62	30·9	83	32·5	78·5	39 5	83	43
1874	..	88·8	41·5	81·8	40·1	88	39·6	81·6	30 6	64	30 3	59 5	26 9	62	26·1	63	28·5	69·2	28·1	70·3	33 7	80	44·1	82	43·6
1875	..	85·2	41·4	80	41·6	80·3	35·8	71·7	36 7	65	32·3	60 4	28·3	62 4	28 5	58·3	29·8	68	31	72	31·8	77·5	32 8	84·8	43·7
1876	..	82 5	40·7	82	48·5	76·4	39 2	72	36·5	77 5	26·5	68·4	24·6	59	23 3	68	27·6	70·8	29·1	77	32	78	36·7	79·4	39·2

This last winter—1899—has been of exceptional severity, and is referred to again (see below in "Acclimatisation"); here I only quote a few temperatures: Sand-dunes one mile from the sea, in Tarata Garden, the thermometer, placed on the ground during June and July, fell several times below 20° Fahr., and on the 26th July registered 15·8° Fahr.; at Hororata—altitude 240 m.—on the same night the minimum temperature registered by a thermometer at Sir John Hall's, placed against the wall of a house facing east and at a height of 44 cm. from the ground, was 6° Fahr. Had the temperature been taken on the grass it would probably have registered 0° Fahr.

The following are some of a few scattered observations which I have made from time to time in the Waimakariri district: At Springfield, altitude 387 m., thermometer on grass on 17th June, 1897, at 8.45 p.m., registered 20·75° Fahr., and at 9.30 p.m. 19·4° Fahr.; on 18th June, at 7.45 a.m., in same position, it registered 19·4° Fahr. On 18th June, 1897, temperature on ground (shingle), at 12.30 p.m., with wind blowing from S.W., near summit of Porter's Pass, 944 m. altitude, was 39·2° Fahr. At Castle Hill, altitude 723 m., during night of above day, minimum was 10·4° Fahr.; on 19th June, during from 8.30 a.m. to 12.30 p.m., maximum was 48·2° Fahr., and minimum 15·8° Fahr.; at 12.30 p.m. it was 40° Fahr. On Longspur Hill, at 1,010 m., facing N.E., at 2.20 p.m. on same day on ground, it was, in sunshine, 37·4° Fahr., and under 5 cm. of snow 31·45° Fahr. At 1,220 m. on Longspur Hill, Craigieburn Mountains, a thermometer left at head of a small shingle-slip facing south during nights of 19th and 20th June, 1897, showed minimum temperature of 17·6° Fahr., almost exactly the same degree of cold being registered below at altitude of 723 m.

The following temperatures were recorded on Arthur's Pass during December and January, 1897–98, the thermometer on the ground in the midst of clumps of *Celmisia armstrongii.*

	Maximum. Deg. (Fahr.).	Minimum. Deg. (Fahr.).		Maximum. Deg. (Fahr.).	Minimum. Deg. (Fahr.).
Dec. 19 ..	59	46·4	Dec. 27 ..	..	26·6
„ 20 ..	67	41	„ 29 ..	94	42·8
„ 21 ..	68	44·6	„ 30 ..	92	45
„ 22 ..	68	28·4	„ 31 ..	67·5	36·5
„ 23 ..	..	33·8	Jan. 1 ..	69·8	46·4
„ 24 ..	89 6	36·5	„ 2 ..	75·2	42·8
„ 25 ..	105·8	44·6	„ 3 ..	73·4	50
„ 26 ..	..	34			

Thirdly, as to Moisture in the Atmosphere.—Saturation = 100. The average per month at Christchurch, Bealey, and Hokitika previous to 1877 was as follows :—

—	January.	February.	March.	April.	May.	June	July.	August.	September	October.	November.	December.
Christchurch ..	73	75	77	77	82	86	83	79	78	72	73	73
Bealey ..	71	71	75	80	81	86	89	84	84	78	78	76
Hokitika ..	81	85	85	86	86	88	89	87	84	86	83	85

Fourthly, as to Direction and Force of Wind.—The average daily force in miles for the year and the maximum velocity in miles in any twenty-four hours at Christchurch and Bealey were as follows :—

—	1868.	1869.	1870.	1874.	1875.	1876.	1877.	1878.	1879.
Christchurch...	..	146–490	137–420	133–519	140–1319	116–691	164–566	167–554	142–656
Bealey ...	97 6–509	90–581	133–750	136–395	142–399	174–654	191–552	232*–665	.

* For ten months only.

I do not think that these figures are very reliable; at any rate, they do not bring home to us the often great violence of the wind. Sir J. Hector, in a note to the Meteorological Report for 1873, writes as follows: "But the local modifications of both force and direction of the wind, due to the influence of mountains and gorges, affect the results even more seriously than the disturbances referred to by the author—Dr. J. Hann. The only reliable observations available in any part of New Zealand are those taken from the motion of the clouds."

The next table, showing the frequency of the various winds, is of great œcological importance. It must be borne in mind that the north, west, and north-west winds are rain-bringing winds in the western part of the region and dry hot winds in the eastern, especially on the Canterbury Plains. The south-west wind is a rain-bringing wind in the east—often snow on the mountains—but the rain comes in great gusts, and is very cold; when unaccompanied by rain it exercises a great check upon vegetable growth, and will, by causing excessive transpiration, blacken young growth of leaves and buds just after the manner of frost. It also often blows for three days at a time, occurring usually after a nor'-wester, and lowering the temperature many degrees in a few hours. The north-east and east winds are not nearly so violent as the south-west and north-west, but they are very steady, also raw and cold, and have a considerable mechanical influence on plant-structure as well as promoting transpiration. The Christchurch records only give an idea of the climate near the sea; more inland

the north-west wind is much more frequent. Often a north-west wind blows in the eastern lower mountain region, while in the lowland maritime region the east wind blows steadily.

—	N.	N.E.	E.	S E	S.	S.W.	W.	N.W.	Calm.
Bealey—									
1869	0	39	1	23	2	32	0	177	91
1870	1	37	1	22	1	25	0	223	55
1871	0	34	0	22	1	21	1	220	66
1872	0	26	1	33	0	22	0	208	76
1873	0	45	7	63	0	35	0	164	51
1874	1	31	10	56	1	22	1	194	48
1875	12	15	18	37	19	16	19	181	53
1876	66	25	21	61	17	15	17	106	45
1877	64	23	6	35	12	15	12	120	81
1878	103	23	9	23	26	26	26	90	50
1879	57	30	10	50	8	12	8	121	67
Christchurch—									
1869	4	48	113	16	9	127	14	23	11
1870	9	43	95	22	23	135	11	21	6
1871	7	105	68	9	21	124	12	14	5
1872	10	90	78	21	15	105	7	30	10
1873	5	97	51	39	21	105	1	39	7
1874	1	121	31	29	11	130	1	41	0
1875	3	96	45	36	8	133	9	35	0
1876	7	101	41	16	9	149	10	32	13
1877	4	128	28	13	7	149	11	25	0
1878	3	117	33	6	4	138	18	46	0
1879	3	94	70	17	5	144	11	21	0

To the heading "Calm" the following note is appended: "These returns refer to the particular time of observation, and not to the whole twenty-four hours, and only show that no direction was recorded for the wind on that number of days."

It will be plainly seen, from reference to the above table, that the prevailing wind of the western region is north-west, and that the prevailing winds in the extreme east are, in order of frequency, south-west, north-east, and east, all more or less cold winds, as before mentioned.

Any account of the climate of the Canterbury Plains would be incomplete without special reference being made to the north-west wind, since it influences vegetation to such an extent, even in the most shady and sheltered positions, as to entirely prevent the growth of certain hygrophytes—*e.g.*, *Hymenophyllums*, *Todea superba*, &c., and they can only be cultivated in Wardian cases, and the like. Sweeping through the river-gorges, it bursts with great fury upon the plain—a hot dry wind, its progress marked by clouds of sand and silt rising out of the bed of the Waimakariri and the other great rivers. In the distance clouds can be seen over the mountains, indicating the rain-storm that is raging there; but over

the plain is a clear blue sky, while a hot sun strikes down. On plants the leaves hang flaccid, in orchards the trees are stripped of their fruit; everywhere the surface of the ground becomes dry as dust. On the dunes clouds of sand are blown back to the sea, sandhills are bodily removed, and the rope-like stems, several metres in length, of *Desmoschœnus* laid bare. In openings in the mountains, such as Porter's Pass, the fury of the storm is something to encounter. Mr. J. Rountree, for many years driver of the West Coast mail-coach, tells me that the coach is sometimes forced to halt near the summit of the pass, unable to proceed except with great risk of being overturned, and that small stones are meanwhile carried with great force through the air. When the north-west wind rages on the mountains, it is frequently impossible to stand upright on a ridge exposed to its full blast. Where such a wind blows even heavy seeds need no special provision for their distribution.

Fifthly, as to Radiation.—Hector writes (*l.c.*, p. 429), "The effect of the prevalence of clouded sky is best illustrated by the average difference between the readings of the black-bulb maximum thermometer in the sun and of the minimum thermometer exposed to the night-sky, and for this purpose two stations on either side of the Southern Alps may be selected:—

—	Christchurch.			Hokitika.		
	Insulation.	Radiation.	Difference.	Insulation.	Radiation.	Difference.
Summer	131·72	44·78	86·94	84·02	48 38	35·64
Autumn	111·92	37·94	73·98	73·04	41·72	31·32
Winter ..	91·22	28·04	68·18	61·70	33·44	28·26
Spring ..	124·25	34·34	90·18	75·02	39 56	35·46
Extremes	158·00	14·54	143·46	97·34	21·92	75·42

Acclimatisation.

The behaviour of introduced exotic plants with regard to hardiness, rapidity of growth, variation in form both externally and internally, or of change with regard to reproduction and the like under their changed climatic conditions, is of great value for furnishing details regarding climate. Information of this kind would be an interesting contribution to plant geography in general, and the subject is well worthy of extended treatment. Here I can only deal most briefly with this matter, confining my remarks for the most part to the question of hardiness, and selecting first of all a few common plants.

The potato is sometimes cut by frost, even so late as November, within one mile of the sea; it is grown with success at times at so cold a station as the upper roadman's hut, Bealey Valley, altitude 762 m. The French bean is grown, at any rate, up to an altitude of 400 m., but at both Castle Hill and Bealey it is killed by frost. The vegetable-marrow has been grown successfully both at Mount White and Bealey. *Pinus insignis* is the common shelter-tree all over the plains; it is quite hardy at Castle Hill, but of much slower growth than in warmer localities. The same remarks also apply to *Cupressus macrocarpa.* The grape-vine, unless when trained against a wall, will not bear fruit in the open; under this treatment it will ripen its fruit even in the central portion of the plains. *Ulex europæus* is a weed of grass-paddocks, sand-dunes, and river-beds, frequently growing to a height of 4 m. or more, and forming impenetrable thickets. At an altitude of 600 m. it ceases to become a weed, the climate perhaps being too severe for the seedlings with their different leaf-structure to the adult, and, although growing well enough when planted, it does not reach any great dimensions. *Hypochæris radicata* ascends to the grassy alpine meadows, occurring even in the more stony ground. The laurel regularly ripens its fruit at Craigieburn in the garden of the homestead, altitude 605 m. The gooseberry has naturalised itself abundantly in the Castle Hill *Fagus* forest, in clearings, and bears abundance of small fruit. *Eucalyptus globulus** grows well at 500 m. altitude, at the base of Mount Torlesse.

Speaking generally, plants of the cold temperate zone will thrive anywhere in the lower mountain and lowland regions, while species belonging to the Mediterranean and Californian floras are usually hardy up to 400 m. Australian and South African plants, those of the higher regions excepted, are not usually hardy even near the sea. The Cape of Good Hope silver-tree, hardy in hilly stations near Dunedin, will not endure even the mildest winter of the Canterbury Plain. *Pelargoniums* and Cape heaths require the protection of a wall near New Brighton, although quite hardy at Sumner, only a few miles distant, where they are sheltered by the Port Hills from the south-west wind.

Although not nearly so favourable a locality as many others in this Island—*e.g.*, Dunedin—exotic alpine plants can be grown even near the sea-coast as easily as in England,

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* This exceptional winter, 1899 (*vide ante*), has killed the leaves, at any rate, of nearly every blue-gum tree in the middle and upper portions of the Canterbury Plains, some of which must have been more than thirty years of age (see Appendix, where are also some observations regarding the laurel).

judging from accounts of their culture in the *Gardeners' Chronicle* and the *Garden;* indeed, such are often much more amenable to cultivation than are those indigenous to our Alps, many of which can only be grown with the greatest difficulty. *Silene acaulis, Dianthus alpinus, D. neglectus, Papaver alpinum, Viola calcarata, Gentiana verna, G. acaulis, Leontopodium alpinum, Anemone sulfurea, A. vernalis, Androsace lactea, Primula farinosa, P. longiflora, P. auricula, Arnica montana, Aster alpinus, Saxifraga aizoides, S. aizoon, S. exarata, Draba aizoides, Campanula pusilla*, to quote some examples from the Swiss alpine flora, all thrive or have thriven in the Tarata Garden. Many other alpines—Himalayan, Andean, Siberian, or North American—could also be quoted.

The successful acclimatisation of any plant belonging to exotic temperate regions in the lowland or lower mountain region seems to depend less upon temperature and rainfall than upon the nature of the soil, and shelter from the prevailing winds. In certain parts of the Canterbury Plain—*e.g.*, near the lower Waimakariri Gorge—the force of the north-west wind has been sufficient to blow away from a newly sown wheat-field both surface-soil and seed. It is in many instances rather New Zealand plants themselves which are difficult to acclimatise than exotics.

Numbers of North Island forest-trees, some from the neighbouring Port Hills, and others from Stewart Island, far to the south, are damaged or killed outright by the cold even near the sea.* In fact, the winter climate of the lowland region, or perhaps of the Canterbury Plain as a whole, is more severe than any other similarly situated region in the South Island, nor is the maritime region much milder than sheltered inland stations at 300 m. altitude.

Phenology.

I am not aware that phenological records have ever been published regarding any part of New Zealand.† Such are of extreme value as a measure of climate. Bailey‡ writes, "Such records are more accurate measures of seasonal climates than instrumental measurements are. Some day"—referring to the United States—"the country will have charts of

* L. Cockayne: "An Inquiry into the Seedling Forms of New Zealand *Phanerogams*" (Trans. N.Z. Inst., vol. xxxi., p. 359).

† Since writing the above I have found an interesting account of the blooming of New Zealand orchids in the Thames district, for which see Trans. N.Z. Inst., vol. xvi.: "On the Botany of the Thames Goldfield," by J. Adams, B.A.

‡ L. H. Bailey: "The Principles of Fruit-growing," New York, 1897, p. 127.

isophenal lines as well as of its isotherms." For these records to be of value they should be kept for a series of years at different stations. The leafing and defoliation of common deciduous trees, the flowering of the same varieties of fruit-trees, the blooming of *Cordyline australis*, *Arundo conspicua*, and *Phormium tenax;* these and many more equally easily observed periodic phenomena would form an excellent record.

I have kept, but unfortunately too irregularly to be of much use, a record for several years of the blooming of many of the plants in my garden. A few extracts may be of interest:—

Chionodoxa sardensis bloomed on the 21st August, 1895; 10th August, 1896; 6th August, 1897; 19th August, 1899.

Narcissus nanus bloomed on the 13th August, 1894; 27th August, 1895; 13th August, 1896; 25th August, 1899.

Narcissus jonquilla bloomed on the 28th August, 1895; 5th September, 1896.

Anemone nemorosa bloomed on the 5th September, 1896; 19th September, 1895.

Veronica formosa bloomed on the 11th October, 1893; 6th October, 1894; 14th October, 1899.

Clematis montana bloomed on the 17th October, 1893; 25th October, 1895; 28th October, 1899.

Aquilegia thalictrifolia bloomed on the 3rd November, 1894; 3rd November, 1895; 29th October, 1899.

Potentilla pennsylvanica bloomed on the 20th December, 1893; 22nd December, 1895; 25th December, 1899.

Kniphofia macoweni bloomed on the 5th January, 1893; 3rd January, 1895; 10th January, 1899.

Of much greater value is a comparison of the blooming, &c., of the same plants at different elevations and in different regions. The following may be accepted as fairly correct:—

Strawberries are ripe near the seaboard at the beginning of December; at the Bealey (640 m. altitude), about the first week in February.

The *double daffodil* blooms in the Christchurch district during the first and second weeks of September, and at Castle Hill (723 m. altitude) towards the middle of November or a little earlier.

Fagus cliffortioides comes into new leaf-growth in Tarata Garden, New Brighton, towards middle of October, and at Castle Hill towards first or second week in November.

Ranunculus lyallii blooms in cultivation near Christchurch from the beginning of October, on Arthur's Pass (911 m. altitude) at end of November and begin-

ning of December, and near the Waimakariri glaciers (1,219 m. altitude) from the middle of January to the middle of February.

Clematis australis blooms in Tarata Garden during middle of October; at Bealey at end of November or beginning of December, and on Arthur's Pass at beginning of January.

Celmisia bellidioides bloomed in Tarata Garden 2nd October, 1895, and on Arthur's Pass at end of December, 1897.

As a general rule New Zealand alpine and subalpine plants bloom in cultivation near sea-level from a month to a month and a half earlier than in the mountains at an elevation of from 750 m. to 1,000 m. The time at which these alpine plants bloom in their natural habitats is probably dependent not on the temperature of the air, but upon the time when the snow melts, and it seems an hereditary habit to bloom at a fixed time after such melting, each species having its own limit of time, some longer some shorter, but dependent in large measure, I think, on the preceding year's climate having been sufficient to produce the incipient bud up to the requisite state of development; while the blooming of the same species in cultivation exposed to a mild winter and spring, and with no covering of snow, must depend upon heredity varied by the climate of the current year.

Some of the alpine plants are so precocious as to put forth their blooms even before the snow is quite away—*e.g.*, *Caltha novæ-zelandiæ*. Buchanan writes,* "The intense heat of the sun at high altitudes is, no doubt, an important element in hastening growth, but the chief cause must be ascribed in many cases to the advanced stage at which the plants have arrived before the melting of the snows in spring has uncovered them. Large plants such as *Ranunculus buchanani* were found 8 in. to 10 in. high, with the leaves and flower-buds fully formed." The phenomenon of *Euphrasia* partly developing its blooms while in the freezing-chamber at Lyttelton seems also a case in point.† Christ‡ describes similar phenomena in the Swiss Alps thus: "Avant que la surface du sol, comprimée par le poids de la neige, ait commencé à se réveiller de sa torpeur, avant même que les bourgeons jaunâtres des herbes aient commencé à pousser on voit s'ouvrir tout près de la neige, et parfois dans la neige même toute une sérée de

* "On the Alpine Flora of New Zealand" (Trans. N.Z. Inst., vol. xiv., 1881, p. 343).

† L. Cockayne: "On the Freezing of New Zealand Alpine Plants" (Trans. N.Z. Inst., vol. xxx., p. 439).

‡ H. Christ: "La Flore de la Suisse et ses origines." Édition Française, Bale, Genève, Lyon, 1883, p. 376.

fleurs des plus fines et des plus délicates, dignes au plus haut degré d éveiller, notre attention et notre sympathie."

Climatic Regions and Plant-formations.

It is well known that many plants are accustomed to grow in company with other plants, and that such communities, or plant-formations as they are often called, occur again and again in different parts of a district without their constituents varying to any great degree. Thus a forest having *Fagus cliffortioides* as its dominant tree may be expected to contain certain other definite plants as undergrowth, while on the trunks of the trees themselves the same mosses and lichens will usually be found. If a portion of such forest be examined in any part of a particular district, noting carefully its plant-members and their relative frequency, it will be found that such a forest will be typical of all others of that class, and that if any marked change occur it will be in a region of considerable difference in climate, soil, or altitude. Again, a stony river-bed will carry certain plants, and such a station, subject to the provisos indicated above, will have the same vegetation, no matter in what part of a district it may occur. Into groups such as these may the flora of a region be divided, and so the relations of each group of plants as a whole with regard to moisture, soil, light, heat, air, and animals be conveniently studied, and the resultant life-forms of the component species noted and considered.

From the foregoing it must not be imagined that a plant-formation is something definite and invariable; on the contrary, hard-and-fast distinctions cannot be made. Transitions occur between most; certain plants enter into a formation in one place which are entirely absent in another, or a plant may have crept in which does not belong to the formation at all. Thus in the *Fagus* formation near Arthur's Pass occurs a solitary example of *Olearia lacunosa*, a plant really belonging to the upper limits of the Westland forest, or sometimes forming a small percentage of the subalpine scrub of that region. Nevertheless, this classifying the plants of any district into communities which resemble one another so much in their adaptations to their environment that they usually grow together is well fitted for the object aimed at—viz., a study of such adaptations—while also from the floristic point of view it is a concise method of mapping the vegetation.

One great difficulty is to properly estimate the effect of the various external factors on plant-life, and statements must necessarily be often based on very uncertain and incomplete observations, especially so indeed in a "new country," where even the most general details as to temperature, composition of soil, rainfall, &c., are not accurately known. Two factors

determine plant-formations—climate and the nature of the soil, the former affecting wide areas usually, and the latter being often very limited in its operation. This has recently been termed by Schimper "edaphic" (edaphisch) (*loc. cit.*, p. 5), and he characterizes the formations as climatic and edaphic respectively.

In what follows I shall use the term "formation"* to include the more or less well-marked smaller communities, while the larger will be called "plant-regions," and will, of course, include numerous plant-formations. By Kerner† the term "formation" is restricted to those communities which are intermingled and exhibit a kind of stratification. A forest with undergrowth of shrubs and a carpet of smaller plants on the ground would be an example; to such Drude‡ gives the name of "formations étagées."

The Climatic Regions.

The moisture-laden north-west wind, hurrying over the Dividing-range, deposits there and in the immediate vicinity large quantities of water. Whatever moisture it still contains falls, as it furiously drives along, upon the eastern spurs and slopes of the Dividing-range, the rain reaching a greater or shorter distance according to the quantity of moisture originally in the air and the velocity of the wind. In very rare cases during a north-west storm a slight shower is experienced at the eastern seaboard; more often the summits of the Mount Torlesse Range experience a more or less heavy downpour or only a trifling shower, while under such circumstances the table-land up to an elevation of 900 m. gets no rain at all, but only a drying tempest. Still more often it is only the actual Dividing-range for a mile or two to the east which gets the rain, and sometimes, indeed, none falls on the eastern side, it being confined to the ridge and mountain-tops. As an example of this, Bealey does not get nearly so much wet weather as the country at the source of the Waimakariri. I have seen rain fall when camped at the mouth of the River

* An account of the meaning of the term "plant-formation" as used by different authors, and an admirable exposition of the aim of œcological plant geography, may be seen in "Natural Science," vol. xiv., p. 109, in an article by Robert Smith, B.Sc., entitled "On the Study of Plant Associations." I have purposely avoided this latter title, and kept to the older one of "plant-formation," since Schimper uses the term—"Die Genossenschaften"—to indicate the more intimate relations between lianes, epiphytes, saprophytes, parasites, and the plants with which they are associated.

† Kerner and Oliver: "The Natural History of Plants," London, 1895, p. 896.

‡ "Manuel de Geographie Botanique," par Dr. O. Drude (French translation and revised edition), Paris, 1897, p. 207.

Crow, six miles from Bealey, which place experienced fine weather the while, and at the same time the downpour on the high ranges added a considerable increase of water to the river. It is quite a common sight to see a heavy storm in progress up the Waimakariri while the sun shines brightly at Bealey. On Arthur's Pass I have observed heavy rain, while down the Bealey Valley, half a mile away, it was quite fine. This great difference between the eastern and western rainfall (see above, "Meteorology") has written its mark most unmistakably upon the vegetation. A line can be drawn which certain plants do not cross usually, and marking what I should take to be the average eastern limit of the north-western rain, and which separates, though not sharply, the district into two great climatic regions—viz., the western and the eastern.

Throughout this and other papers dealing with the same subject I purposely refrain from speaking dogmatically as to the range of plants. The distribution of New Zealand plants is still too imperfectly known to allow definite statements to be made, and most of such that have been published up to the present are not of much scientific value. *Ranunculus lyallii*, a common western subalpine plant, and one which would not be thought to exist on the dry eastern hills, is found in an isolated station near Lake Lyndon. *Metrosideros lucida*, another western plant, occurs on dry rocks at Broken Hill.* *Celmisia lyallii*, a most typical eastern plant, with, according to Diels, the structure of a steppe grass (*loc. cit.*, pp. 265 and 268), has been collected in the neighbourhood of Cook River, Westland, by Mr. Wilson, formerly District Surveyor, Hokitika. These extreme cases show that it may be possible to find any eastern plant in the western region, and *vice versâ*, in one or more isolated stations, and the same reasoning applies to north and south limits and altitudinal range for New Zealand plant geography generally. But this should not hinder us from designating certain plants as "eastern," "western," "northern," "southern," "alpine," "lowland," and the like with perfect propriety. The other climatic divisions of these two regions depend upon altitude, and may be classed as "lowland," "lower mountain," "subalpine," and "alpine." All four occur in the eastern region, but only the two latter to any extent in the western, so far as the Waimakariri system is concerned. The Trelissick basin, a part of the eastern lower mountain region, almost forms a distinct climatic region, owing to its peculiar position with regard to the

* Another station in this district is the forest near Patterson's Creek, Mount Torlesse, whence I have received specimens collected by Mrs. J. G. L. Scott.

mountain-ranges which bound it and set down both the north-west and the south-west rains. Thus it often rains at Lake Pearson when the higher ground of the Trelissick basin is rainless; and, again, it may rain on the Canterbury Plains and on Mount Torlesse and yet the region under consideration be dry. Perhaps the Trelissick basin bears more resemblance œcologically to Central Otago than to any other region in New Zealand.*

The Eastern Climatic Plant-region. — The œcological character of this region is essentially xerophilous.† This is not to be wondered at when the small rainfall and constant drying winds in conjunction with the usually stony soil is considered. To be sure, there is much swampy ground, but such to many of its inhabitants is physiologically dry. Schimper writes (*loc. cit.*, p. 4), "In der That ist ein sehr nasses Substrat für die Pflanze vollkommen trocken, wenn sie ihm kein Wasser zu entnehmen vermag, während ein Boden, der uns vollkommen trocken erscheint, manche genügsame Pflanze hinreichend mit Wasser versorgt. Es muss zwischen physikalischer und physiologischer Trockenheit, bezw. Feuchtigkeit unterschieden werden; letztere allein kommt für das Pflanzenleben, also auch für die Pflanzengeographie in Betracht." Diels, in a long list embracing plants of varying stations (*loc. cit.*, pp. 216, 217) with regard to moisture, classifies them all as hygrophytes, evidently more from their station than from their structure.

Phormium tenax, *e.g.*, usually a denizen of swamps, occurs also on dry river-terraces, on sand-dunes, and even on dry faces of rock—upper Waimakariri Gorge. *Leptocarpus simplex*, a curious restiaceous plant, lives equally well either in brackish marshes or on sand-dunes. In cultivation in my garden, on an almost perpendicular rockery, exposed to the full rays of the sun and to the north-west wind, *Epilobium macropus*, whose usual habitat is cold running water in subalpine streams, thrives amazingly, yet receiving exactly the same treatment as *Paronychia argentea*‡ of the Mediterranean region, side by side with the former, and in excellent health. *Claytonia australasica* grows both in shallow running water and on shingle-slips.

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* The plants of Central Otago are distinguished in Petrie's list by the mark C (Trans. N.Z. Inst., vol. xxviii., 1895, p. 540).

† Plants of the pine forest and certain marsh plants form an exception to this; also, the New Zealand *Fagi* are classified by Schimper as tropophytes, on account, I suppose, of the conspicuous young-leaf growth during early spring, and the often deciduous habit of the most exposed branches.

‡ Nicholson for this plant recommends a light dry soil: "The Illustrated Dictionary of Gardening," London, vol. iii., p. 25.

Besides these many other instances could be quoted of bog plants or those of very wet stations growing on dry ground.* The stony character of the ground, with a gravelly subsoil at a greater or lesser depth (see Plate XIII.), has been mentioned when treating of the topography of this region. On the mountains clayey loam is often found, varying much in its percentage of clay; also very stiff clay is met with, but always underlain by rocky *débris*, and so subject to rapid desiccation. In addition to these are characteristic xerophilous stations, such as rocks, stony river-beds, salt meadows, sandhills, and shingle-slips. The rivers, as pointed out before, flow in beds often deep down below the surrounding country, much of which consists of steep slopes, so that every facility is provided for natural drainage.

To support a luxuriant vegetation in such a region would require a moist atmosphere and a considerable rainfall. On the contrary, the rainfall on the plains near the sea is little more than 20 in., increasing, of course, as the hills are neared; on the alpine heights and at the north and west boundaries it is much greater still, but possibly decreasing to below that of Christchurch, in the Trelissick basin. In addition to this the wind is nearly always blowing, sometimes a violent, hot, dry nor'-wester, sometimes a cold, dry sou'-wester, at other times a steady, drying, east or north-east wind. The sun, too, is hot in summer, and cloudless days prevail. In winter clear frostless days with warm sunshine are common. Excessive weather, too, is not unknown; two periods of drought have occurred during the past ten years. In 1895 the snow lay near the sea for more than a week, and skating on ice was possible in that neighbourhood, while on the table-land and the mountains the snow lay for many weeks longer than its average period. This winter of 1899 has been specially referred to in dealing with the meteorology, but other periods of cold almost as great have occurred during the past twenty years.

Low-lying hollows in the alpine region are filled with water one month and dry the next. The stones on shingle-slips become so hot that it is unpleasant to touch them with the hand, while the night of that same day may witness a frost. In such a station the plants are often frozen quite hard before being protected by their winter covering of snow, and while in this state are exposed to drying winds. Some plants, again, grow in stations where the winter snow can never protect

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* See also Goebel, "Pflanzenbiologische Schilderungen," zweiter teil, Marburg, 1891, pp. 46, 47, where he quotes certain plants which are found in Germany in bogs, but in the arctic regions on dry hills; and species of *Espeletia*, in the Venezuelan Andes, grow both in marshes and on rocks.

them, on, *e.g.*, the final rocky precipices of a mountain peak. These examples may give some idea of the climate that the plants of this region must endure in many instances.

To the above conditions of soil and climate the plants have responded in various ways. The details of such adaptations will be entered into more fully when dealing with the constituents of the formations; here it is only necessary to point out a few of the more common adaptations assumed by plants frequently enough to affect the general plant physiognomy of this region.

Where constant and often furious winds blow it is necessary that the plants should protect themselves in some way or another from being broken or torn to pieces. But such winds, besides acting in this mechanical way, also indirectly exercise a most powerful physiological effect upon plant-life by causing excessive transpiration. And how enormous must such transpiration be during a hot nor'-wester! That plants even when frozen can be killed by excessive transpiration is pointed out by Schimper (*loc. cit.*, p. 45). Nor is such transpiration confined to leafy plants; even deciduous trees in the cold winter of Michigan, U.S.A., may be damaged through excessive transpiration through the bark (Bailey, *loc. cit.*, pp. 13–18). Bearing these facts in mind, the cold high winds of winter must also have a powerful influence upon plants.

Many of the commonest forms of our plants are adaptations against the effect of wind, and serve at the same time both to resist its violence and to reduce transpiration in many cases to its smallest limit. Reduction of transpiration is also controlled by other means, to be treated of in due course. One very common form which meets the end in view is a round ball-like growth of the entire plant, and is to be seen in great perfection in numbers of shrubby plants—*e.g.*, *Veronica traversii*, *Hymenanthera alpina*, T. Kirk (var.), and *Plagianthus divaricatus*, this latter growing in salt meadows, a station physiologically dry. In the cases cited the very close-growing, divaricating, often intertwining branches shelter very considerably both themselves and their leaves, presenting a surface which the wind cannot damage, and so ball-like are many—*e.g.*, *Veronica odora*—that they look as if trimmed into that shape purposely by a gardener; indeed, few things are more strange than to see a clump of these perfectly globe-shaped bushes with their varnished green leaves, the whole looking like some portion of a cultivated shrubbery, away up a distant river-bed, where man may never have set foot before. Even in sheltered places in cultivation these plants still maintain this habit, which is evidently quite hereditary. The well-known tussock form of certain grasses and sedges serves the same purpose, and is a most distinguishing form of the entire

region. Such close growth of branches is carried to its extreme limit in *Raoulia eximia* (Plates XI., XII.), an inhabitant of rocks facing north and north-west in the alpine regions, whose branches are so close that they form a compact coral-like mass, upon which one can sit down without affecting its shape in the slightest degree.

Excessive transpiration is also combated in many plants by reduction of their leaf-surface, the most obvious method of which is by reducing the size and number of the leaves. This is carried to such a pitch that some plants have few or no leaves at all. Among the most common are the *Carmichaelias* of this region, whose assimilating functions, &c., are performed entirely by the stems, in which a most excessive stereome tissue produces great inflexibility and wind-resisting power.

Another very common method of avoiding rather than combating the wind is low or prostrate growth, a very common feature in the alpine region, and seen in the lowland and lower mountain region amongst the *Carmichaelias*, with stiff, erect, leafless branches 2 cm. or 3 cm. high, which form large patches on the stony ground, or in the trailing, almost leafless *Muhlenbeckia ephedrioides*, or, most of all, in the moss-like river-bed *Raoulias*—a most efficacious method, since it is well known that the force of the wind is much stronger at some distance from than close to the ground.

Plants covered with dense masses or mats of hair are frequent, by which not only transpiration but extreme temperatures are guarded against. Such plants are especially characteristic of the alpine or subalpine region. Compare, *e. g.*, *Craspedia alpina* of the shingle-slips, quite snow-white with its thick covering of woolly hairs, with its much less hairy relative *C. fimbriata*, var., of lowland swamps, or with its thin-leaved almost hygrophilous relative of the west.

Numerous grasses have rolled leaves. Other plants have the leaves incurved or recurved, all methods for reducing leaf-surface. But I will enter into no more details now, except to point out that Diels was much struck with the extreme xerophilous character of many plants, which he considered out of all proportion to any severity of climate they have now to endure, for, according to him, at the present time the driest regions of New Zealand are less arid and possess a more equable climate than middle Europe—"dass selbst die trockensten Striche Neuseelands unter minder excessivem Klima und seltener Dürren leiden als Mitteleuropa" (*loc. cit.*, p. 247); and so he considered *Carmichaelia*, *Hymenanthera*, *Corokia*, and some others to be descendants of a forest flora which had been forced to retreat northwards during a rising of the land which led to the

formation of a dry easterly steppe region, where the survivors of the forest had become modified, and assumed the structure and physiognomy of desert plants. I shall refer to this again when treating of these plants, but I think the observations recorded in this paper show a climate in the east quite sufficient even at the present day to account for structure so xerophilous as that of *Carmichaelia nana*.

That these adaptations are really for the purpose of resisting drought, and that they have been evoked by a dry climate, has been more or less proved in certain instances. Goebel was the first to show that *Veronica cupressoides*, when cultivated in moist air, produced true leaves, with stomata on both surfaces, and which were strictly of an extreme hygrophilous type.* At about the time of the publication of this experiment Mr. R. Brown was engaged in similar experiments here. He cultivated pot plants of *Raoulia tenuicaulis*, *Ozothamnus microphyllus*, and *Veronica armstrongii* in his greenhouse, the glass of which was not shaded, with the result that all produced leaves differing much from the wild plants.† I have repeated Goebel's experiment, and find that *Veronica cupressoides* is so unstable that it will produce these reversion leaves in six weeks' time when cultivated under a bell glass and kept constantly moist. Under the same conditions all the other whipcord *Veronicas*—*V. lycopodioides*, *V. hectori*, &c.—will equally rapidly produce reversion leaves. Nor is it always necessary to give such moist treatment as the above. Rooted cuttings placed in a fairly sheltered spot in a flower border will revert so far as the young growth is concerned, though such reversion will be soon succeeded by normal growth. In my shade-house this spring both *V. tetragona* and *Ozothamnus microphyllus* are rapidly developing true leaves. Other plants with adaptations against drought of other kinds will also under similar treatment change their leaf-form. *Olearia cymbifolia*, planted in the open border, will often produce a growth of flat leaves, instead of the normal leaf with strongly revolute margins. This change seems to have a tendency to remain more or less permanent, a plant growing on the extreme summit of a rockery in my garden having leaves not nearly so revolute as the type. Another plant in the shade-house for nearly twelve months has now every leaf flat. On the other hand, plants growing in cultivation in a dry part of the garden show no change. The similar behaviour of *Carmichaelia* (any leafless species), *Raoulia eximia*, and *R. bryoides* could also be cited.

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* Pflanzenbiologische Schilderungen Erster Teil, Marburg, 1889, pp. 19, 20.

† Regarding Brown's work, see also Cockayne (*loc. cit.*, p. 360).

Although the artificially produced leaves mentioned above are reversions to the seedling form,* and therefore hereditary, all the same they are in such experiments as these evoked directly by the environment, and they show how xerophytes may be changed into hygrophytes by excessive moisture in the air. Soon after these hygrophilous conditions are removed a plant with reversion leaves will develope ordinary shoots once more. The plant of *Veronica cupressoides* used for the experiment quoted above, although still in a fairly moist atmosphere (that of a greenhouse), is producing normal growth. Whether in cases such as these, where both the reversion leaves and the ordinary leaves, or cladodes, are hereditary, continual treatment under artificial conditions would keep the plant permanently changed, or whether in a moist climate such as that of Westport or Greymouth the reversion form would endure under natural conditions, can only be ascertained by experiment.†

Generally speaking, the plant-life of the whole of this region is scanty. It is only in certain places where shelter, richer and deeper soil, or moisture favour growth that anything like luxuriance may be seen. To the casual observer a hillside in the lower mountain region would seem clad merely with dry, brown tussock-grasses, but careful search will reveal a number of lowly plants growing in the shelter that such tussocks afford. The same remarks apply to the higher regions, where many of the plants are small, low-growing, often moss-like. and by no means numerous on the expanse of clayey or stony dry ground. Since the conditions of soil and climate do not permit a luxuriant plant-covering over considerable areas, it seems hard to understand how introduced plants can have spread so abundantly. Even in 1869 Mr. J. F. Armstrong recorded 178 for Canterbury, and this list has been since extended in the "Students' Flora of New Zealand." Now, the land on which such especially flourish is that which has been reclaimed by man, the rich drained swamp lands and their environs, or even the more stony ground ploughed and made suitable for plant-life. In such virgin soil, inhabited formerly by plants which would not require quite the same food-material, introduced plants would flourish and have flourished amazingly. On ground untouched

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* Cockayne., *loc. cit.*, p. 357.

† From what is said above it seems evident that the two cases (*Olearia cymbifolia* and *Veronica lycopodioides*) mentioned by Captain Hutton in "Darwinism and Lamarckism" (New York and London, 1899, pp. 217, 218) are both examples of one and the same phenomenon, and not—the former an example of an acquired habit which had not become hereditary, and the latter an example of an acquired habit which had become hereditary.

by cultivation mainly those species have firmly established themselves which are specially fitted by their structure to the environment. Thus, to choose two out of many examples, *Verbascum thapsus*, a most tomentose plant, is abundantly naturalised on many river-terraces (Kowai River and River Porter, *e.g.*), and *Lupinus arboreus** on the sand-dunes. Had the numerous weeds arrived before the ground was prepared for them by man they would have met with a much more stubborn resistance in the undrained *Phormium* swamps, &c. Statements such as that by Wallace,† of white-clover wiping out *Phormium*, should be accepted with great caution. Such swamps even now possess few introduced plants, and remain virtually intact.‡

This eastern climatic region may be conveniently divided into the following subregions:—

(1.) The Lowland Region: This embraces the country drained by the Waimakariri, on the Canterbury Plain, and extends from the ocean to the foot of the ranges. It varies in altitude from sea-level to 457 m. Here (excepting towards its western boundary) snow rarely lies for more than twenty-four hours, usually melting as it falls. The rainfall varies on an average from less than 25 in. on the sand-dunes to more than 40 in. at 457 m. This last estimate is a mere guess; but it is a fact that that altitude gets rain from both north-west and south-west which never reaches the sea-coast, and that rainy days must also be much more abundant. The north-west and south-west winds have been already treated of. The former is much more frequent in the western portion of this region, and often blows there with great violence, while a steady east wind is being experienced at the coast and for some miles inland. The rain from the south-west coming in squalls often does not wet the ground on the sheltered side of large plants, so the smaller ones growing there remain quite dry. Frosts may occur during any month except December, January, or February. After rain the ground in most places dries very rapidly. The whole of the region is exposed to the full blasts of the winds, except-

* *L. arboreus* is furnished with exceedingly succulent stems, made up of abundant water tissue. Its leaves also are hairy on the under-surface, and they have the power of reducing the leaf-surface considerably through the two upper sides of the lamina of each leaflet folding together. The leaves exposed to the sun may thus be seen closed up, and those in the shade open wide.

† "On Darwinism," London, 1889, p. 28.

‡ Every student of New Zealand plant geography should read carefully Mr. Cheeseman's very excellent paper, "The Naturalised Plants of the Auckland Provincial District" (Trans. N.Z. Inst., vol. xv., 1882, p. 268). He has gone into the subject of the spread of weeds at some length, and come to some very just and well-considered conclusions.

ing such small tracts as are sheltered by river-terraces. The only other shelter is from the few plantations of exotic trees—mostly *Pinus insignis* and *Eucalyptus globulus*—and gorse hedges which have been planted by the settlers. The vegetation may be divided primarily into the following plant-formations:—

Name of Plant-formation	Most Characteristic Plant.
1. The moving sand-dune	*Desmoschœnus spiralis.*
2. The fixed sand-dune	*Discaria toumatou.*
3. The salt meadow	*Plagianthus divaricatus.*
4. The flowing water	*Myriophyllum elatinoides.*
5. The brackish water	*Zostera nana.*
6. The lowland swamp	*Phormium tenax.*
7. The lowland forest	*Podocarpus dacrydioides.*
8. The grassy meadow	(*)
9. The stony river-bed	*Raoulia tenuicaulis.*

Besides the above formations, several minor divisions will be treated of. It is not always easy to select the most characteristic plant; cases frequently occur in which various plants could be chosen with equal propriety.

(2.) The Lower Mountain Region: This varies in altitude from 457 m. to 761 m., and includes the foot-hills of Mount Torlesse and Mount Puketeraki (in part); the whole of the table-land, including the Trelissick basin, where it ascends to over 900 m., also the valleys of the Esk, Poulter, and Upper Waimakariri to about 761 m. The climate of this subregion may be gathered from what has gone before, and varies from extremely dry in the Trelissick basin and vicinity of the Mount White homestead to very wet with many rainy days and a considerable amount of fog and cloud at its junction with the western climatic region. The ground is mostly extremely stony, consisting of a great depth of stones, sometimes quite without soil, and repeating on the river-terrace slopes the shingle-slips of the higher levels in miniature. With the exception of the Trelissick basin the whole of this subregion is wetter than the lowland subregion, but the loss of water in the soil, owing to the great depth and slope of the stony ground, is much more rapid. Swampy ground is of frequent occurrence, and streams are abundant. Before joining a main river the tributaries usually stretch out into huge fans, with remains of older fans bounding them. On such a fan coming

* This formation will be subdivided into several minor formations, each with a different characteristic plant, depending in large measure upon the depth of the soil. Large stretches of very stony, arid, barren land are occupied by *Leptospermum scoparium*, especially towards the centre of the Canterbury Plain, on the north bank of the river.

from Mount St. Bernard into the Winding Creek are a most surprising number of forms of two species of *Veronica*. Numerous grass-fires, bush-fires, a certain amount of cultivation, and the pasturage of many sheep have in some places changed the character of the vegetation, especially so far as percentage of components is concerned, and by destroying the tussock shelter must have almost or entirely eradicated some of the more lowly plants. The following are the most important plant-formations:—

Name of Formation.	Most Characteristic Plant.
1. The mixed *Fagus* forest . . .	*Fagus solandri.*
2. The rock	*Veronica raoulii.*
3. The river-bed	*Epilobium melanocaulon.*
4. The shingle-slip	(*)
5. The grassy meadow	Tussock of *Festuca duriuscula.*†
6. The terrace scrub	*Veronica traversii.*
7. The marsh	*Carex gaudichaudiana.*
8. The lake	*Isoëtes alpina.*
9. The running stream	*Montia fontana.*

Besides the above formations, other smaller ones will be treated of. Some of the lowland and subalpine formations also extend into this region.

(3.) The Subalpine Region: This region is of great interest, and contains many remarkable plants. It is here that the effect of varied stations on plant-form can be especially well studied. For example, it is hard to believe that *Epilobium chloræfolium* of a very shady station among shrubs is the same species as the form growing in the open. All the mountainous country between an altitude of 761 m. and 1,220 m. found in the eastern climatic region belongs to this subregion. Snow lies on an average for about one month during winter, but for a longer period towards the upper portions of the region, and, of course, in times of a heavy snowfall, for considerably longer still. Frosts may occur during any month in the year. The south-west wind often brings rain. Not uncommonly is the soil of fair depth, in that case consisting of yellow, rather sandy, clayey loam. Heavy winds are frequent, but on the whole there are more calm days than in the lowlands. The surface of the ground is usually very steep,

* The shingle-slips have to be subdivided into limestone and sandstone, each bearing a somewhat different set of plants.

† Several subdivisions will here also be necessary. Perhaps *Aciphylla colensoi* should have been given as the principal plant; it is certainly most characteristic of the whole region in many ways, and it gives a peculiar and special physiognomy to the landscape where growing in abundance.

except in river-beds and their vicinity and on the mountain passes. Streams are often abundant. As an example of the great permeability of the soil with regard to water, I may mention that the water of a waterfall of considerable volume descending from the eastern slopes of Mount Torlesse sinks completely underground at a few metres below the fall, while at a few metres above there is also no sign of water, except during heavy rain. In this case the water-channel is very steep. Kaka Creek, at the base of Broken Hill, behaves in a similar manner; indeed, for the water of a river suddenly to disappear through its shingle is of quite common occurrence in all the South Island mountains. The chief plant-formations of this region are:—

Name of Plant-formation.	Most Characteristic Plant
1. The *Fagus* forest	*Fagus cliffortioides.*
2. The subalpine scrub	*Dracophyllum uniflorum.*
3. The subalpine meadow	*Celmisia lyallii.*
4. The river-bed ..	*Epilobium polyclonum.*
5. The running stream	*Epilobium macropus.*
6. The marsh and wet ground	(*)
7. The rock	(†)

The *Fagus* forest descends into the montane region, where it often occurs on the shady side of river-terraces sheltered from the north-west. The shingle-slip to be mentioned in the next subregion also frequently descends into this. Several smaller formations will also be considered.

(4.) The Alpine Region: This extremely interesting and important region extends from 1,220 m. to 2,134 m. It includes all that portion of the mountains which lies above the winter snow-line, consequently its plants undergo pressure by the snow and exclusion from light unknown to those of lower regions. The rainfall is certainly greater than that of the subalpine zone, and the wind on the exposed portions of the mountains much stronger. Frost will be more severe than in the subalpine region, but no statistics exist on this head as yet with regard to New Zealand. According to Schimper (*loc. cit.*, p. 727), the air-temperature decreases at the rate of 0·58° C. for each 100 m. This would give a difference of 5·2° C. or 9·3° Fahr. between the temperature of the highest and lowest parts of the region, so far as the air was

* These will include several minor formations, differing in great measure upon the amount of stagnation of the water.

† The plants of wet rocks, of course, differ from those of dry rocks, so here some minor distinctions will have to be drawn.

concerned, or a difference of 14·6° between the middle of the Trelissick basin (609 m.) and the summit of Mount Enys (2,134 m.). This excess of cold is met by the protecting action of the snowy mantle which covers all the alpine region except certain precipitous rocks near the very summits. Even these unprotected spots have their phanerogamic vegetation*; on one such in the Craigieburn Mountains, at an altitude of 1,980 m., I have noted *Cardamine enysii* and *Veronica epacridea* growing in profusion, in places during January the rocks being white with blossoms of the former. Summer snowstorms are frequent, especially during south-west wind, but sometimes also coming from the north-west. The rainfall varies according to position with regard to north-west rain; thus it is certainly greater on the summit of the Craigieburn Mountains than on Mount Torlesse. This heavier rainfall and greater frequency of rainy days has caused in favourably situated stations a richness of vegetation approximating to the western region, and even some of the western plants make their appearance—*Senecio scorzonerioides, e.g.* The sky is frequently cloudless, and insolation stronger than in any other region. There is no comparison at times between this direct action of the sun and the temperature of the air. It may be most delightfully warm on one side of a gully, sitting in the sunshine, and on the other, at hardly the distance of two metres away, bitterly cold, ground and plants being frozen hard. Temperatures such as these have been measured in various parts of the world. Hooker† writes, "This effect (solar radiation) is much increased with the elevation; at 10,000 ft., in December, at 9 a.m., I saw the mercury mount to 132° with a difference of + 94°, while the temperature of shaded snow hard by was 22°." The moisture in the atmosphere at times when the mountains are clothed with cloud and mist must be very considerable. On the other hand, during the clear weather the rarified atmosphere must be very dry. It is a beautiful and interesting sight from an elevation of 1,200 m. on Mount Torlesse, the sky overhead clear, to look down upon a great level stretch of white dense cloud marking the Canterbury Plain. The soil and subsoil are much the same as in the subalpine region, but streams are less frequent, and towards the summits altogether wanting. Moist ground with permanent lagoons sometimes occurs. Many of the slopes consist of shingle-slips, sometimes made

* Similar examples are given by Christ (*loc. cit.*, p. 295) from Switzerland, where on the Col de St. Théodule, which has an average temperature for the year of − 5·59° C., a minimum of − 21·4° C., and a maximum of 15·1° C., with an altitude of 3,333 m. above the sea, thirteen species of flowering-plants grow.

† Himalayan Journals, vol. ii., London, 1854, p. 410.

up of quite loose stones, at other times of firmer consistency, and with a greater or less amount of finely triturated particles of sandstone, yellow in colour, and perhaps containing small amounts of clay. From these shingle-slips rocks not yet disintegrated crop out in places, sometimes several metres in height and sometimes at the level of the shingle, presenting the driest of physically dry plant-stations. The plant-life consists in large measure of cushion and patch plants, bearing a most striking resemblance to many Andean plants, so far as œcological characters are concerned—*e.g.*, *Maja compacta*, of New Granada, looks like *Heliophyllum colensoi*; *Verbena minima*, of Peru and Bolivia, like *Raoulia grandiflora*; or *Loricaria ferruginea* like *Veronica lycopodioides*. Many of the subalpine plants ascend to this region; some of the lowland and lower mountain are also found here. Others seem to be confined to stations where snow lies for a long period every year, and if they are found elsewhere it is most unusual—*e.g.*, *Luzula pumila*, *Celmisia viscosa*. The principal plant-formations are:—

Name of Plant-formation.	Most Characteristic Plant.
1. Alpine meadow	*Celmisia laricifolia.*
2. Rock	*Raoulia eximia.*
3. Shingle-slip	*Ligusticum carnosulum.*

The soil of the alpine meadow is often very patchy, there being in many places only narrow strips between shingle-slips, or there may be oases of good soil here and there on the surface, and on the margins of these deserts of shingle. The shingle-slip plant-formation is an edaphic formation of the very greatest interest, and may be divided into the unstable or shingle-slip proper and the more stable shingle-slip, which latter contains a much larger variety and number of plants. Some of the shingle-slip plants are, so far as I know, never found in any other station—*e.g.*, *Ranunculus haastii*, *Stellaria roughii*, *Ligusticum carnosulum*, *Craspedia alpina*, *Lobelia roughii*, *Cotula atrata*, *Cotula dendyi*, sp. nov., MSS., mihi, *Notothlaspi rosulatum*, *Epilobium pycnostachyon*, and *Poa sclerophylla*.

The Western Climatic Plant-region.—This region, so far as it concerns the country here treated of, is an outlying easterly portion of the great western plant region, which extends on the west side of the great Dividing-range right from the north to the south of the South Island of New Zealand, and whose flora has only been examined in a few places. The small portion treated of here, properly speaking, only occupies the

actual ridge of the Dividing-range, as far as the upper limit of the subalpine *Fagus* formation. This latter formation, however, contains many western plants, especially in its upper portion (*e.g.*, *Panax colensoi*, *P. lineare*, &c.), and it forms a distinct natural barrier which shuts off the eastern from the western plants. Its much greater extent and its different constituents separate it from the eastern *Fagus* formation, and so, although strictly neither eastern nor western in character, it seems more correct to include it in the western plant region. Some western plants also occur at its eastern limit, such as *Gunnera dentata*, *Hymenophyllum armstrongii*, and *Carmichaelia grandiflora*, and this, too, would form a reason for placing it as I have done. The climate of this western region has been indicated already from the meteorological reports of Hokitika and Bealey, but the rainfall must be very much greater than at either of these places; indeed, I should not be at all surprised to learn that it amounted on an average to 200 in. yearly, or even more. The number of rainy days must be very much greater than on the Westland lowland.

During a stay of six weeks on the summit of Arthur's Pass (900 m.) in the months of December and January, 1897–98, I had an opportunity of learning some little about the climate. During that time it rained on more than half the days, the rain sometimes lasting for two days and a half at a time. There was one heavy thunderstorm. My tent, situated on a usually quite dry spot, was not unfrequently filled with water to a depth of 15 cm. The wind blew north-west during the whole of the six weeks, with the exception of a few hours, when a south-west wind gave a slight sprinkle of snow. Once, too, it also snowed from the north-west. The wind blew often with enormous force. Had our tents not been sheltered by trees they would have been frequently levelled to the ground. This excessive wind has written its mark on the vegetation (Plate X.), where the tussocks of *Danthonia raoulii* are all bent to the south-east. Often when not raining on the pass it was doing so on the adjacent heights, and when raining on the pass was fine in the Otira Gorgè (W.). During the fine weather it was extremely hot, so much so as to make climbing an exertion. For a few days before our arrival it had been fine, and then the ground and all the vegetation was so dry that one had to be most careful when lighting a fire not to set the forest in a blaze. A creek near the camp was perfectly dry, and so were many watercourses; yet the rain previous to these few fine days had been excessive for weeks! Snow lay (December) all over the hills above a height of 1,200 m., and in the river-beds and hollows in the mountains would be quite 15 m. deep in many places. As an example of how deep snow may be

in the New Zealand Alps, Haast says* that in October he had found by actual measurement 48 ft. of snow on Browning's Pass, and further, on page 31, he writes, "It is difficult to describe my astonishment when I looked down a frightful gorge with nearly vertical rocky walls about 800 ft. high. It was on the snow which had filled up this precipice that we had ascended five weeks previously. In estimating the altitude of the slope where we thus travelled up from the gully at 300 ft. I think I rather over- than under-estimated it. This would leave 500 ft. as the depth of snow in the gorge" At the sources of the Bealey, the Poulter, and Nigger Creek every year great masses of snow must accumulate, and also the extensive subalpine meadow flora just at the terminal face of the Waimakariri Glacier must experience a tremendous pressure from drifted snow. By the end of January (to continue the account of observations on Arthur's Pass) a great deal of snow had melted, the mountains were almost bare, but still there remained a great depth at the head of the Bealey River, under the precipices of Mount Rolleston. The thermometric records, which were not kept very regularly, may be seen in the portion of this paper relating to meteorology; they show the great variations of temperature which occur even in the middle of summer. During the time of excessive north-west wind and rain described above the eastern climatic plant-region was experiencing a great drought, whose effects would be heightened by the constant hot drying winds, and serious bush-fires raged in many parts of the Canterbury District, especially near Oxford.

The south-west wind seems to exert a great influence on the distribution of the vegetation in this region. The Westland subalpine scrub never occurs where the full force of this cold wind can strike it; in such situations only *Fagus* formation exists. Thus the Dividing-range has on its eastern a vegetation of an entirely different physiognomy to that on its western face, and in some cases these two œcologically different formations occur within a few metres of one another. It is only in sheltered gorges or protected within the forest that the peculiar Westland subalpine plants can live. At the eastern base of Walker's Pass, in a moist sheltered hollow into which two waterfalls descend, and protected completely from the south-west by a rocky wall, grows *Senecio latifolius*, a Westland hygrophyte. In sheltered places up Punch-bowl Creek, Bealey Valley, is *Dracophyllum traversii*, and the solitary plant of *Olearia lacunosa* before mentioned may be observed from the coach-road, sheltered in the forest near the summit of Arthur's Pass.

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* Report on Head-waters of River Rakaia, Christchurch, 1886, p. 30.

In December, 1898, while on an excursion with Professor K. Goebel, we had an opportunity of observing the vegetation of this region under conditions of dryness, for during the fortnight we were in Westland only a few quite local showers occurred. In the usually extremely moist forest near Greymouth the filmy fern *Trichomanes reniforme* was generally found with its fronds quite withered up and apparently dead. So dry was the subalpine scrub on Arthur's Pass that some of a survey party with whom we were camped, climbing Mount Rolleston, set fire to a considerable portion. Much of the usually swampy ground was quite dry, and the plants which generally were surrounded by water were growing on extremely dry ground. Outwardly, except as shown by the presence of certain hygrophytes, there appeared nothing to indicate an extremely moist climate.

From this short account of the climate it may be seen that the plants of this western region have to endure considerable extremes so far as wet and drought are concerned, and with this as one consequence amongst other factors the vegetation is essentially xerophilous. A few hygrophytes and tropophytes are also met with, but under exceptional circumstances. Thus in a climate having an abnormally great rainfall, and an atmosphere usually charged with much moisture, we meet with plants whose structure seems more suitable for deserts. Such are sclerophytes with tomentose leaves and strong stems (*Senecio viridis*); herbs with leaves whose internal morphology calls to mind the steppe grasses—Diels, *l.c.*, p. 265 (*Celmisia armstrongii*); shrubs with much-reduced leaves (*Pittosporum rigidum*); plants whose stems, furnished with coriaceous imbricating leaves, form dense cushions (*Donatia novæ-zelandiæ*); tufted plants formed of hard rosettes of incurved, imbricating, needle-shaped leaves, the whole pressed close to the ground (*Celmisia sessiliflora*), &c. All the same, the plants as a whole, when compared with those of the eastern climatic region, are not of quite so extreme a xerophilous structure; nothing is here found to approach in that particular the vegetable-sheep or the coral-broom (*Corallospartium*) of the eastern ranges. Many plants have considerable leaf-development, and a much greater luxuriance of growth generally is apparent. The alpine and subalpine meadows are like meadows, and not mere patches of plants surrounded by stony wastes. In the east the subalpine scrub occurs only here and there, but here it forms a great belt at the limit of the upper forest.* The never-ending war which is waged for the supremacy between

* Cockayne, "On the Burning of Subalpine Scrub" (Trans. N.Z. Inst., vol. xxxi., p. 400).

tree-forms and grassy meadows, described by Schimper (*loc. cit.*, p. 176) has here, in the lower regions, resulted in a complete victory for the trees, which cover with a dense black mass the basal portions of the mountains. In the east, on the contrary, the grasses have vanquished, and tussock meadows rule supreme. The western may be divided into similar subregions to the eastern region, with much the same limitations as regards altitude that have been proposed for the latter. They are, however, only two in number, if we omit for the present certain grassy river-flats (since no part of this region descends much below 762 m.)—viz., the subalpine region and the alpine region:—

(1.) The Subalpine Region: This occupies all the eastern slopes of the Dividing-range below a height of 1,220 m., and has its lower limit at the line of the average north-west rainfall. It includes the following plant-formations:—

Name of Plant-formation.	Most Characteristic Plant.
1. *Fagus* forest	*Fagus cliffortioides.*
2. Subalpine scrub	*Phyllocladus alpinus.*
3. Marsh	*Donatia novæ-zelandiæ.*
4. Wet meadow	*Celmisia petiolata.*
5. Rock	*Helichrysum grandiceps.*
6. River-bed	*Raoulia haastii.*
7. Running stream	*Montia fontana.*
8. Meadow	*Ranunculus lyallii*

Nearly all these formations will be subdivided into minor formations, &c., and there are some others which will receive attention.

(2.) The Alpine Region: Here the snow certainly lies longer and the snowfall is greater than in the eastern alpine region. It extends from the upper limit of the subalpine region to the mountain summits, if below the snow-line, or to the glaciers and the perpetual snow. According to Haast the glacier at the head of the White River descends to 1,300 m. with its terminal face, and that up the Crow River to 1,372 m. (*loc. cit.*, pp. 147, 148). Many of the plants are the same as those of the eastern alpine region, but these usually when truly eastern are few in numbers—*e.g.*, the very common *Celmisia spectabilis* of the east is here rare and local. The plant-formations will be given the same names as those of the east, for the most part, and so need not be enumerated until treated of in detail.

At various places on the dividing-range are low passes, in height from 908 m. to about 1,200 m. In such places the ground is usually flat, well watered, and in places swampy.

Huge rocks and masses of coarse *débris* abound, and generally there are mountain tarns and waterholes. Here the subalpine becomes mixed with some of the alpine vegetation; the plants grow in profusion and with great luxuriance, forming when in bloom, from the end of November till the end of January or middle of February, beautiful natural flower-gardens.

APPENDIX.

The following notes on the effect of the severe winter of 1899 on plants, more especially on native trees and shrubs at Hororata, were most kindly furnished by Sir John Hall:—

(1.) *List of New Zealand Trees and Shrubs damaged by the Frosts of June and July, 1899.*

Olearia forsteri in nearly every instance was completely killed; it has suffered perhaps more than any other native tree, even when completely sheltered. Height in some instances, 7 ft.

O. traversii very badly damaged; in most cases killed outright; in other cases the lower parts were unhurt.

Veronica salicifolia (plant 5 ft. high) completely killed.

Pittosporum eugenioides and *P. tenuifolium* in most cases were considerably damaged, especially towards the tops. A hedge of *P. tenuifolium* which had been kept closely clipped suffered very severely, every leaf being browned, but it may possibly recover.

Drimys axillaris suffered badly in some cases.

Panax arboreum has suffered very badly, and most likely in many cases has been killed outright.

Clianthus puniceus killed outright.

Griselinia littoralis for most part undamaged, but many leaves have dropped off, apparently through the effect of the frost.

Podocarpus totara slightly browned in places, but virtually quite unhurt.

Senecio greyii considerably damaged.

(2.) *New Zealand Plants growing at Hororata which were not damaged.*

Olearia avicenniæfolia.
" *illicifolia.*
" *furfuracea.*
" *insignis.*
Gaya lyallii.
Senecio compacta.
" *monroi.*

Cassinia fulvida.
Hoheria angustifolia.
Sophora microphylla.
Veronica macroura.

(3.) *Exotic Plants which were undamaged.*

Quercus ilex (Mediterranean).

Eucalyptus gunnii (Tasmanian). In many instances quite small plants fully exposed were undamaged.

Choisya ternata (Mexican).

Cistus ladaniferus, in three varieties (Mediterranean).

(4.) A fine laurel hedge is very much damaged. Almost every leaf on the west side is killed, while on the other side the hedge is still quite green. The undamaged side was not exposed to the wind, while the damaged portion received a slight westerly breeze.

EXPLANATION OF PLATES X.–XIII.

Plate X.

Portion of a subalpine meadow in the western region, with *Celmisia armstrongii* in bloom and tussock of *Danthonia raoulii*, showing effect of prevailing wind.

Plate XI.

Raoulia eximia growing on Mount Torlesse, eastern climatic region, at 1,500 m. altitude. On sky-line is a man seated on a plant of *R. eximia*, giving some idea of its size.

Plate XII.

Raoulia eximia, as in No. 2, in bloom, and with *Celmisia spectabilis* growing on and round it. Same locality as No. 2.

Plate XIII.

Eastern plant-region. The stony nature of the ground may be seen in the piece of river-terrace, on top of which *Phormium* is growing. River-terrace of River Waimakariri before entering lower gorge.

ART. XVIII.—*Notes on the New Zealand* Musci.

By ROBERT BROWN.

[*Read before the Philosophical Institute of Canterbury, 2nd August, 1899.*]

Plates XIV., XV.

Genus BARTRAMIA (Hedwig).

THE genus *Bartramia* is composed of beautiful mosses, with their habitats principally on wet banks and rocks, on stones in streams, and on rocks under the spray of waterfalls. They are an alpine and subalpine genus, and are popularly known as "apple mosses," from the subrotund form of their capsules, which are large and very conspicuous.

The generic description of the genus is: *Capsules* globose, furrowed when dry, erect, cernuous, or pendulous. *Peristome* double, single, or none. *Teeth:* Outer 16, lanceolate, equidistant; inner membranous, bifid, sometimes with alternate cilia. *Calyptra* dimidiate. *Leaves* papillose.

In the "Handbook of the Flora of New Zealand" some of the species placed in this genus have pyriform capsules, although the generic description is "globose"; possibly they have been placed in this genus owing to their specific characters being those of *Bartramia.* That arrangement I have followed in this paper.

The species described in this paper as *B. hallerianioides* is the *B. halleriana* of the Handbook, which is a European species. The great general resemblance of the New Zealand moss to the European one has led to the mistaken description of these two as identical. A critical examination of the two plants has disclosed the following differences between them: The capsule of the New Zealand plant is nearly one-half smaller, obliquely subrotund, mouth oblique, insertion of the fruitstalk with the capsule very oblique. In the other plant the capsule is symmetrical, mouth not oblique, and the insertion of the fruitstalk is central at the base of the capsule. In the former the leaves are more spreading, and the back of the nerve is spinulose, serrated; while in the latter the back of the nerve is smooth.

Another mistake has also occurred in the identification of one of the New Zealand species of *Bartramia* as *B. pomiformis* (a European moss) in vol. xxix., p. 443, of the "Transactions and Proceedings of the New Zealand Institute." Mr. Beckett has there recorded this identification, which was copied from a manuscript list of mosses sent by Mr. W. Bell to Dr. Brotherus, to be named by that gentleman. This

identification is evidently a clerical mistake, as Dr. Brotherus has not published it. *B. pomiformis* has no erect sheathing-base to the leaves. while in the New Zealand moss the bases of the leaves are erect and sheathing.

I have seen no specimens of *B. affinis*, which is a Tasmanian moss, originally described and figured in the "Musci Exoticæ" by W. J. Hooker. The capsule is there figured and described as being spherical, and the leaves with their margins strongly recurved, while the capsule of *B. affinis* of the Handbook is described as being "ovoid." This is evidently a mistake, some other moss having the margins of the leaves recurved having been mistaken for the Tasmanian one. In the species treated in this paper there are only two which have the margins of their leaves recurved; one of them slightly, the other strongly. The latter is the one which is commonly taken by New Zealand botanists for *B. affinis*. It is described in this paper as *B. revisa*.

I have been unable to identify any of the following species: *B. crassinervia*, Mitt., *B. affinis*, *B. consimilis*.

There are two characters in the leaves of the plants in this genus which are useful as a means of classification, forming two very distinct sections—First, leaves having erect sheathing-bases; second, leaves without sheathing-bases. I have adopted this arrangement in the key.

Key to the Species mentioned and described in this Paper.

Section A: Leaves more or less erect, and sheathing at the base.

1. *Bartramia patens*, Brid.
2. " *gibsonii*, sp. nov.
3. " *brevifolia*, sp. nov.
4. " *robusta*, Hook. f. and Wils.
5. " *hallerianioides*, sp. nov.
5a. " *halleriana*.
6. " *papillata*, Hook. f. and Wils.
7. *Bartramia linearifolia*, sp. nov.
8. " *robustifolia*, sp. nov.
9. " *divaricata*, Mitt.
10. " *revisa*, sp. nov.
11. " *comosa*, Mitt.
12. " *bellii*, sp. nov.
13. " *sieberi*, Mitt.

Section B: Leaves without sheathing-bases.

14. *Bartramia hapuka*, sp. nov.
15. " *erwinii*, sp. nov.
16. " *ovalitheca*, sp. nov.
17. " *tenuis*, Taylor.
18. " *joycei*, sp. nov.
19. " *turnerii*, sp. nov.
20. " *australis*, Mitt.
21. *Bartramia pyriforma*, sp. nov.
22. " *remotifolia*, Hook. f. and Wils.
23. " *buchanani*, sp. nov.
24. " *pendula*, Hook.
25. " *elongata*, Mitt.

Section A.

Leaves more or less erect, and sheathing at the base.

1. Bartramia patens, Bridel.

Species diœcious, growing in dense tufts 1 in. high, yellowish-green above, dark-brown below, subdichotomously

branched. *Branches* ¼ in. long. *Leaves* closely imbricating, erecto-patent from an erect sheathing quadrilateral base, subulate, semiconvolute, dilated or auricled at the apex; margins minutely serrated from the sheathing-base to the apex, papillose on the back, nerved to the apex. *Areola:* Upper quadrate; lower long, linear; leaves slightly flexuous when dry. *Perichætial leaves* smaller than the other ones, sheathing at the base. *Fruit* acrocarpous. *Fruitstalk* about ¼ in. long. *Capsule* oval, obliquely connected with the fruit-stalk, furrowed when dry. *Mouth* small, oblique. *Operculum* convex.

Hab. Wet banks, Mount Fife, Kaikoura; January, 1899. Collected by R. B.

2. **Bartramia gibsonii**, sp. nov.

Plants monœcious, growing in dense tufts ½ in. high, pale-green above, brown below, dichotomously branched. *Branches* ⅜ in. long. *Leaves* closely imbricating, erecto-patent, subulate, with an erect quadrilateral sheathing-base, semiconvolute; margins minutely serrated from the upper part of the sheathing-base to the apex; nerve continuous, papillose on the back of the leaf. *Areola:* Upper quadrate; lower linear; slightly flexuous when dry. *Perichætial leaves* linear, subulate, tapering from the base into a slender point. *Fruit* acrocarpous. *Fruitstalk* ½ in. high, red, obliquely attached to the capsule. *Capsule* subrotund. *Operculum* shortly conical.

Hab. On wet banks, near the River Hapuka, Kaikoura; January, 1899. Collected by R. B.

3. **Bartramia brevifolia**, sp. nov.

Plants monœcious, growing in dense tufts 1½ in. high, yellowish-green above, brown below, branched. *Branches* fastigiate, ¼ in. long, densely radiculose. *Leaves* suberect, imbricating, short, subulate. Base erect, sheathing, quadrate at the upper sides of the sheath; margins minutely serrated; nerve indistinct upwards, excurrent; back of leaves papillose. *Areola:* Upper small, dense, quadrate; lower linear-oblong; leaves introflexed near the top when dry. *Perichætial leaves* erect, subulate, slender, longer than the stem ones, without sheathing-base. *Fruit* acrocarpous. *Fruitstalk* red, slightly flexuous, ¾ in. long. *Capsule* ovate, slightly oblique. *Mouth* wide. *Peristome* double; outer teeth 16, lanceolate, red; inner, a membrane divided to the middle into 16 teeth. *Operculum* not found. *Calyptra* cucullate.

Hab. Wet banks and rocks, Mount Torlesse; January, 1886. Collected by R. B.

4. **Bartramia robusta,** Hook. f. and Wils.

Plants monœcious, growing in tufts in patches 2 in. high, pale- or yellowish-green, radiculose. *Stem* fastigiately branched. *Branches* $\frac{1}{2}$ in. high. *Leaves* imbricating, spreading from an erect sheathing quadrate base, linear lanceolate or subulate, semiconvolute, somewhat brittle; margins serrated, papillose on the back; nerve excurrent. *Areola:* Upper dense, quadrate; lower oblong; scarcely altered when dry. *Perichætial leaves* short, slender, erect, subulate. *Fruit* acrocarpous. *Fruitstalk* slightly flexuous, red, $\frac{1}{2}$ in. high. *Capsule* inclined, subrotund, slightly oblique. *Mouth* small.

Hab. Wet rocks, Mount Torlesse; January, 1886. Collected by R. B.

5. **Bartramia hallerianioides,** sp. nov.

Plants synœcious, growing in large tufts 1 in.–5 in. high, green or yellowish-green above, brownish below, radiculose, sparingly branched. *Branches* projecting above the capsules. *Leaves* imbricating, spreading, subulate; base erect, quadrilateral sheathing papillose; margins spinulose, serrated; nerve excurrent, spinulose, serrated on the back, crisped when dry. *Areola:* Upper small, quadrate; lower linear. *Perichætial* leaves small, erect, tapering into a long slender point. *Fruit* acrocarpous. *Fruitstalk* red, $\frac{1}{8}$ in. long. *Capsule* oblique, subrotund. *Operculum* short, conic. *Peristome* double; outer teeth 16, lanceolate, dense; inner, a membrane divided for two-thirds of its length into 16 keeled teeth, bifid at the apex. *Calyptra* small, cucullate.

Hab. Wet rocks, Port Lyttelton hills, and common near Lake Te Anau. Collected by R. B.

6. **Bartramia papillata,** Hook. f. and Wils.

Plants diœcious, growing in small tufts, pale-green, $\frac{1}{4}$ in.–$\frac{3}{4}$ in. high. *Stems* slightly radiculose, branched. *Branches* fastigiate, $\frac{3}{4}$ in. long. *Leaves* imbricating, slender, erecto-patent, subulate from a narrow erect sheathing quadrilateral base, auricled at the apex, semiconvolute, minutely serrated on the margin, and papillose on the back; nerve excurrent. *Areola:* Upper small, quadrate, dense; lower oblong. *Perichætial* leaves erect, smaller than the stem ones, slender, subulate from an oblong-lanceolate base. *Fruit* acrocarpous. *Fruitstalk* $\frac{3}{16}$ in., inclined. *Capsule* rotund, oblique. *Mouth* small, oblique. *Peristome* double; outer teeth 16, free to the base; inner, a membrane divided to the middle into 16 teeth. *Operculum* and *calyptra* not found.

Hab. Wet banks, West Coast Road; January, 1886. Collected by R. B.

7. **Bartramia linearifolia**, sp. nov.

Plants growing in small tufts $\frac{3}{4}$ in. high, yellowish-green above, brownish below. *Stems* slender, radiculose, branched. *Branches* few, $\frac{1}{4}$ in. long. *Leaves* closely imbricating, erecto-patent, linear, subulate from an erect sheathing-base, semiconvolute; margins serrated, back papillose; nerve indistinct, excurrent. *Areola:* Upper dense, quadrate; lower oblong, slightly dilated at the apex; leaves nearly erect when dry. *Perichætial leaves* longer than the stem ones, erect, linear-lanceolate, acute. *Fruit* acrocarpous. *Fruitstalk* inclined, $\frac{1}{4}$ in. to $\frac{3}{16}$ in. long. *Capsule* oval. *Mouth* small.

Hab. Wet banks, near Broken River; January, 1886. Collected by R. B.

8. **Bartramia robustifolia**, sp. nov. Plate XIV.

Plants growing in large tufts 2 in. high, pale-green. *Stems* radiculose. *Branches* subdichotomous, $\frac{1}{2}$ in. long. *Leaves* imbricating, spreading, stout, lanceolate, subulate from a broad obovate erect sheathing-base, semiconvolute; margins serrated; back papillose; nerve excurrent. *Areola:* Upper dense, quadrate; lower narrow, oblong; leaves flexuous when dry. *Perichætial leaves* as long as the stem one, erect, ovate-lanceolate, tapering into a subulate point. *Fruit* acrocarpous. *Fruitstalk* $\frac{3}{4}$ in. long. *Capsule* erect, ovate. *Operculum* conic, obtuse.

Hab. Clinton River, head of Lake Te Anau. Collected by R. B.

9. **Bartramia divaricata**, Mitt.

Plants growing in tufts or patches $1\frac{1}{2}$ in.–$2\frac{1}{4}$ in. high, yellowish-green above, brown below. *Stems* densely radiculose, branched sparingly, $\frac{1}{2}$ in. long, fastigiate. *Leaves* closely imbricating, spreading, lanceolate, acuminate, from a short, erect, quadrate sheathing-base; margins flat, serrated, papillose on the under side; nerve slender, excurrent, becoming spinulose, serrated towards the apex. *Areola:* Upper small, oblong; lower linear; leaves unaltered when dry. *Perichætial leaves* very small, erect, oblong, rounded to a short hair-point. *Fruit* acrocarpous. *Fruitstalk* red, flexuous, $\frac{5}{8}$ in. long. *Capsule* subhorizontal, pyriform, furrowed when dry; other parts not found.

Hab. Stones in streams, West Coast Road; February, 1883. Collected by R. B.

10. **Bartramia revisa**, sp. nov.

Plants diœcious, growing in dense patches, yellowish-green or green, 1 in.–3 in. high, subdichotomously branched. *Stem* radiculose. *Leaves* closely imbricating, spreading, or erecto-

patent, linear-lanceolate, tapering into a slender point, semi-convolute; base erect, short, sheathing; margins papillose, strongly recurved, papillose on back and nerve; nerve excurrent. *Areola:* Upper small to near the base, dense; lower small, quadrilateral; leaves erect, and points of the branches cuspidate when dry. *Perichætial leaves* small, oblong-lanceolate, apiculate. *Fruit* acrocarpous. *Fruitstalk* $\frac{1}{3}$ in. to $\frac{1}{2}$ in. long, curved at the apex. *Capsule* ovate, pendulous, variable in breadth, furrowed when dry. *Peristome* single, 16, slender, distinct. *Operculum* conic.

Hab. Wet rocks, Port Lyttelton hills; 1886. Collected by R. B. and by Donald Petrie.

11. **Bartramia comosa,** Mitt.

Plants diœcious, growing in dense patches, yellowish-brown above, brown below, 1 in.–2 in. high, densely radiculose, subfastigiately branched. *Branches* $\frac{1}{4}$ in.–$\frac{5}{8}$ in. long. *Leaves* closely imbricating, spreading, upper ones slightly sheathing, ovate-lanceolate, acuminate; middle ones shortly sheathing; margins slightly recurved at the middle, serrulate towards the apex, papillose, plicate near the base; nerve excurrent, long, slender. *Areola* small, dense, above quadrilateral, below linear, erect when dry. *Perichætial leaves* erect, one-half smaller than the upper ones, deltoid, acuminate; nerve disappearing below the apex. *Fruit* acrocarpous. *Fruitstalk* $\frac{1}{4}$ in.–$\frac{3}{8}$ in. long, curved at the apex. *Capsule* elliptic, horizontal, or pendulous, furrowed when dry. *Operculum* small, conic, minutely apiculate. *Peristome* double; outer 16, linear-lanceolate; inner, membranous.

Hab. Wet rocks, Beaumont; October, 1891: D. Petrie.

12. **Bartramia bellii,** sp. nov.

Plants growing in dense patches 2 in. high. *Stems* radiculose, subdichotomously branched or nearly simple, unequal in length, $\frac{3}{8}$ in.–$\frac{5}{8}$ in. *Leaves* closely imbricating, spreading, or erecto-patent from a short erect sheathing-base, ovate-lanceolate, acuminate, tapering into a slender point; margins minutely toothed, slightly recurved near the base, minutely papillose; nerve excurrent; leaves not plicate. *Areola:* Upper small, linear, becoming longer towards the base. *Perichætial leaves* shorter than the upper ones, erect, oblong-lanceolate, tapering into a slender point; nerve ending about the middle. *Fruit* acrocarpous. *Fruitstalk* flexuous, 1 in. long, curved at the apex. *Capsule* broadly ovate, oblong, furrowed when dry.

Hab. Wet rocks, near Lake Harris; February, 1895. Collected by W. Bell.

13. **Bartramia sieberi,** Mitt.

Plants diœcious, growing in dense patches $4\frac{1}{2}$ in. high, yellowish-green above, brown below. *Stem* radiculose, branched, simple or dichotomous, $\frac{1}{2}$ in.–1 in. long. *Leaves* short, closely imbricating, spreading, and erecto-patent, subulate from a short broad sheathing-base, lanceolate, concave, plicate; margins serrated, recurved near the base, papillose on the back; nerve excurrent. *Areola:* Upper small, quadrate; lower narrow, oblong; scarcely altered when dry. *Perichætial leaves* short, erect, deltoid, acute; nerve slender, excurrent. *Fruit* acrocarpous. *Fruitstalk* flexuous, red, $1\frac{1}{4}$ in. long. *Capsule* horizontal or pendulous, furrowed when dry, oblong, pyriform. *Peristome* double; outer 16, linear-lanceolate; inner, membranous, 16. *Operculum* shortly conic. *Calyptra* cucullate.

Hab. Rocks, banks of Teremakau River.

SECTION B.

Leaves without sheathing-bases.

14. **Bartramia hapuka,** sp. nov. Plate XV.

Plants growing in dense patches $1\frac{1}{2}$ in. high, yellowish-green above, brown below. *Stems* radiculose, $1\frac{1}{4}$ in. high; innovations fascicled. *Leaves* closely imbricating, small, erecto-patent, ovate, acuminate, concave; margins recurved, serrated; nerve excurrent. *Areola* small, quadrilateral; leaves erect when dry. *Perichætial leaves* similar to the upper ones. *Fruit* acrocarpous. *Fruitstalk* pale, $\frac{5}{8}$ in. long, flexuous. *Capsule* inclined very obliquely, subrotund. *Mouth* small, oblique, furrowed when dry. *Peristome* double; outer teeth 16; inner shorter than the outer, membranous, divided into 16 processes. *Operculum* convex. *Calyptra* cucullate.

Hab. Wet banks, River Hapuka, near Kaikoura; January, 1898. Collected by R. B.

15. **Bartramia erwinii,** sp. nov.

Plants diœcious, growing in dense patches $\frac{1}{2}$ in. – 1 in. high, yellow-green above, brown below. *Stems* slender, radiculose; innovations fascicled, $\frac{3}{8}$ in. *Leaves* small, closely imbricating, secund, erecto-patent, lanceolate, acuminate, ending in slender points; margins slightly recurved, serrated, nerved, keeled, excurrent. *Areola* quadrate; leaves scarcely altered when dry. *Perichætial leaves* smaller than the stem ones, otherwise similar. *Fruit* acrocarpous. *Fruitstalk* $\frac{5}{8}$ in. long, flexuous, reddish. *Capsule* ovate, inclined, obliquely connected with the fruitstalk. *Mouth* oblique, furrowed when dry. *Peristome* double; outer teeth 16, free to

the base; inner, a membrane divided nearly to the base into 16 processes. *Operculum* shortly conic. *Calyptra* cucullate.

Named after Rev. Dr. Erwin, Christchurch.

Hab. Stones, in streams, Benmore; January, 1897. Collected by R. B.

16. **Bartramia ovalitheca,** sp. nov.

Plants diœcious, growing in dense patches 1½ in.–2½ in. long, yellow-green above, brown below. *Stems* slender, radiculose; innovations slender, fascicled, ½ in. long. *Leaves* closely imbricating, nearly erect, small, ovate-lanceolate, acuminate, tapering into a slender point, concave; margins serrated; nerve excurrent, serrated. *Areola* quadrate, leaves erect; appressed when dry. *Perichætial leaves* erect, slightly smaller than the stem ones, linear-lanceolate, tapering from the base into a slender point. *Fruit* acrocarpous. *Fruitstalk* slender, reddish, ¾ in.–1 in. long, inclined. *Capsule* ovate, nearly symmetrical, furrowed when dry. *Operculum* shortly conic. *Peristome* double; outer teeth 16, lanceolate, free to the base; inner, membranous, perforated and laciniated. *Calyptra* cucullate.

Hab. Wet rocks, Mount Torlesse; January, 1886. Collected by R. B.

17. **Bartramia tenuis,** Taylor.

Plants diœcious, growing in small loose patches ½ in. high, yellowish-green above, brown below. *Stem* short, slender; innovations fascicled, slender. *Leaves* small, closely imbricating, erecto-patent, ovate-acuminate, point slender; margins serrated, papillose; nerve slender, excurrent. *Areola* small, quadrate; leaves unaltered when dry. *Perichætial leaves* about one-half smaller than the upper ones, ovate-acuminate. *Fruit* acrocarpous. *Fruitstalk* ½ in. long, inclined. *Capsule* oblong, obliquely attached to the fruitstalk. *Mouth* oblique. *Operculum* conic, furrowed when dry. *Peristome* double; outer 16, linear-lanceolate; inner, membranous, laciniated.

Hab. Damp banks, Paterson's Creek, Otarama. Collected by R. B.

18. **Bartramia joycei,** sp. nov.

Plants growing in loose patches 1 in. high, yellowish-green above, brown below. *Stem* radiculose; innovations fascicled, ¼ in.–⅜ in. *Leaves* closely imbricating, secund, recurved, ovate-acuminate, tapered into a slender point, concave; margins serrated; nerve excurrent. *Areola* quadrate; leaves scarcely altered when dry. *Perichætial leaves* as long as the upper ones, but narrower, erect. *Fruit* acro-

carpous. *Fruitstalk* inclined, 1 in. long, reddish. *Capsule* very obliquely attached to the fruitstalk, horizontal, 1 to 4 in the perichætium, very oblique, oval, ventricose. *Mouth* small, oblique. *Capsule* furrowed when dry. *Peristome* double; outer 16, linear-lanceolate, free to the base; inner, 16, membranous, bifid. *Operculum* and *calyptra* not found.

Named after John Joyce, Papanui.

Hab. Wet banks, near Lake Te Anau; January, 1890. Collected by R. B.

19. **Bartramia turnerii,** sp. nov.

Plants growing in loose patches 1 in. high, yellowish-green above, brown below. *Stem* radiculose; innovations fascicled, ½ in. long. *Leaves* small, closely imbricating, spreading, subsecund, slightly flexuous, shortly lanceolate, tapering into a slender point, concave; margins serrated; nerve excurrent. *Areola* quadrate; leaves scarcely altered when dry. *Perichætial leaves*, inner smaller than the outer one, ovate-acuminate, tapering into a slender point. *Fruit* acrocarpous. *Fruitstalk* slightly flexuous, inclined, 1¼ in. long. *Capsule* ovoid, irregular in outline, very obliquely attached to the fruitstalk, horizontal, ventricose. *Operculum* small, short, conic, acute. *Peristome* double; outer teeth 16, linear-lanceolate, free to the base; inner, 16, bifid at the apex. *Calyptra* cucullate.

Named after Thomas Turner, seed-merchant, Christchurch.

Hab. Wet banks, near River Teremakau, West Coast; January, 1886. Collected by R. B.

20. **Bartramia australis,** Mitt.

Plants diœcious, growing in dense patches 1½ in. high, yellowish above, brown below. *Stems* radiculose, stout; innovations fascicled, stout, ½ in.–⅝ in. high. *Leaves* imbricating, erecto-patent, lanceolate, acuminate, tapering into a slender point; margins serrated, papillose on the back; nerve excurrent. *Areola:* Upper small, quadrate; lower slightly larger; leaves scarcely altered when dry. *Perichætial leaves* erect, slender, smaller than the stem ones, linear-lanceolate, acuminate, continued into a slender point. *Fruit* acrocarpous. *Fruitstalk* flexuous, reddish, 1¼ in. long. *Capsule* horizontal, very obliquely pyriform, gibbous at the base, furrowed when dry. *Mouth* small, oblique. *Peristome* double; outer teeth 16, free to the base, linear-lanceolate; inner, 16, opposite the outer, thickened on the margins, bifid. *Operculum* shortly conic and acute. *Calyptra* small, cucullate.

Hab. Wet rocks, near River Teremakau; January, 1886. Collected by R. B.

21. **Bartramia pyriforma,** sp. nov.

Plants diœcious, growing in dense patches 1 in.–3½ in. high, yellow-green above, brown below. *Stems* radiculose, simple or dichotomously branched below; innovations slender, fascicled, ½ in.–1 in. long. *Leaves* small, closely imbricating, secund, erecto-patent, broadly ovate-lanceolate, acuminate or cordate-acuminate continued into a slender point, concave; margins serrated; nerve excurrent, minutely toothed near the apex, papillose. *Areola* quadrate; leaves nearly erect when dry. *Perichætial leaves* smaller than the upper ones, but otherwise similar. *Fruit* acrocarpous. *Fruitstalk* flexuous, red, 1¼ in. long. *Capsule* horizontal or inclined obliquely, obovate, with a tapering base, slightly gibbous, furrowed when dry. *Mouth* small, oblique. *Operculum* small, conic, acute. *Peristome* single, 16, linear-lanceolate. *Calyptra* cucullate.

Hab. Rocks dripping with water, near Lake Te Anau; January, 1890. Collected by R. B.

22. **Bartramia remotifolia,** Hook. f. and Wils.

Plants diœcious, growing in loose patches ½ in.–1 in. high, glaucous, pale-green. *Stem* simple, radiculose; innovations fascicled, ⅛ in. long. *Leaves* imbricating; lower stem ones erect, ovate, acuminate; upper spreading, with an ovate base, tapering into a long slender point; papillose margins, subrecurved, slightly serrated towards the apex; nerve pellucid, excurrent; leaves closely imbricating, spreading, papillose. *Areola* quadrate; leaves nearly erect when dry. *Perichætial leaves* narrower and shorter than the upper; stem leaves linear-lanceolate, tapering into a long slender point. *Fruit* acrocarpous. *Fruitstalk* 1 in. long, inclined, red. *Capsule* large, obliquely attached to the fruitstalk, obliquely oval. *Mouth* small, oblique. *Operculum* convex, furrowed when dry. *Peristome* double; outer 16, linear-lanceolate, free to the base; inner, 16, membranous, free to the base. *Calyptra* not found. Leaves on the male plant erecto-patent.

Hab. Wet banks, Port Lyttelton hills; January, 1886: banks, near Waimakariri; December, 1887. Collected by R. B.

23. **Bartramia buchanani,** sp. nov.

Plants diœcious, growing in dense patches, yellowish-green above, green at the middle, brown below, 1 in.–3½ in. high. *Stems* radiculose below; innovations fascicled, ⅜ in.–½ in. high. *Leaves,* upper closely imbricating, spreading, ovate-lanceolate, acuminate, tapering into a slender point; margins serrated, back minutely papillose; nerve slender, excurrent. *Areola* small, linear-oblong; leaves flexuous when dry. *Peri-*

chætial leaves erect, smaller than the upper ones, lanceolate, acuminate, tapering into a slender point, innermost smallest. *Fruit* acrocarpous. *Fruitstalk* flexuous, red, 1½ in. long. *Capsule* inclined, obliquely pyriform, gibbous near the base. *Mouth* small, oblique. *Capsule* furrowed when dry. *Peristome* double; outer teeth 16, free to the base, linear-lanceolate; inner, membranous, 16. *Operculum* not found.

Hab. West Coast Road; February, 1883. Collected by R. B.

24. **Bartramia pendula,** Hook.

Plants diœcious, growing in dense patches 1 in.–3½ in. high, yellowish-green above, brown below. *Stems* erect, radiculose; innovations fascicled, ¾ in.–1¼ in. long. *Leaves* closely imbricating, erecto-patent, ovate-lanceolate, acuminate, tapering into a slender point; margins serrated; nerve slender, excurrent, under-surface papillose. *Areola:* Upper small, quadrate; lower linear; leaves incurving when dry. *Perichætial leaves* erect, smaller than the upper ones, linear-lanceolate, acuminate, tapered into a slender point. *Fruit* acrocarpous. *Fruitstalk* flexuous, red, 1½ in. long. *Capsule* horizontal or pendulous, oblong-pyriform, furrowed when dry. *Operculum* convex. *Peristome* double; outer 16, free to the base; inner, membranous, bifid to the middle.

Hab. Damp banks, Milford Sound; January, 1890. Collected by R. B.

25. **Bartramia elongata,** Mitt.

Plants diœcious, growing in large loose patches 2 in.–7 in. high, yellow-green. *Stems* very stout, curved, prostrate, ascending; innovations simple or dichotomously branched. *Leaves* closely imbricating, secund, spreading or erecto-patent, recurved, falcate, furrowed, pellucid, ovate-lanceolate, acuminate; margins distantly toothed; nerve slender, excurrent into a papillose hair-point. *Areola* oblong-linear; alar large, quadrate; leaves scarcely altered when dry. *Perichætial leaves* smaller, erect, linear-lanceolate, innermost acute, outer acuminate with a short hair-point, nerveless. *Fruit* acrocarpous. *Fruitstalk* stout, red, slightly flexuous. *Capsule* horizontal, large, oblong, pyriform, slightly gibbous at the base, furrowed when dry. *Peristome* single, 16, with membranous margins. *Operculum* and *calyptra* not found.

Hab. Wet rocks, near Teremakau River; January, 1886; and near Lake Te Anau; January, 1890. Collected by R. B.

EXPLANATION OF PLATES XIV., XV.

Plate XIV. *B. robustifolia*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.

Plate XV. *B. hapuka*, sp. nov.

1. Capsule.
2. Peristome.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaves.
6. Middle leaf.

Art. XIX.—*Notes on the New Zealand* Musci: *On a Proposed New Genus.*

By Robert Brown.

[*Read before the Philosophical Institute of Canterbury, 4th October, 1899.*]

Plate XVI

In June, 1889, while botanizing in Stewart Island, in the narrow valley which extends from Paterson's Inlet to Mason's Bay, on the west coast of the island, I found the moss which is the subject of this paper. On the northern side of this valley, nearly opposite Mr. W. Walker's house, a small rill runs from the side of the hill and spreads out on the flat ground, forming a kind of sub-marsh, and it was here the moss was found. It was confined to a space of about 20 yards in diameter, and was in great abundance, but, being an annual, it was long past maturity.

In form the capsules of this moss resemble those of the genus *Trematodon*, to which it has a close affinity. No trace of a peristome was found, and from the condition the capsules were in it was doubtful if they had not been destroyed.

I again visited Stewart Island in January, 1892, with the hope that among the specimens collected there might be perfect specimens of the above-mentioned moss. On the morning after my arrival at Mr. Walker's station I started for the habitat where I had found this moss so plentiful on a former occasion, but on arriving there I found that a fire had passed over the place, destroying all trace of the plants. Thinking that there might be other habitats of this moss found in the valley, I commenced a systematic search of it from one end to the other, but without seeing a single specimen. I then extended the search into a branch of the valley which ended on the sea-beach opposite the Ruggedy Isles, and this also

ended in disappointment, no specimen being seen. Subsequently I reached Mr. Traill's Waterfall Run, at the head of Paterson's Inlet, and quite unexpectedly found the plants I had been seeking for so long growing at the end of the station house in perfect condition and in great abundance, but, as in the former case, they were confined to a small area. They appear to be extremely local, and are perhaps rare. I have seen them growing in no other place in New Zealand.

After a careful examination of the perfect specimens the previous diagnosis which I had made of this moss was confirmed—that, although approaching closely to the genus *Trematodon*, it could not properly be placed in that genus, owing to the absence of a peristome, and the calyptra being mitriform.

In order that the species may be properly placed, I have created a new genus, which I have named *Stirtonia*, after Dr. James Stirton, of Glasgow, an eminent cryptogamist, who has contributed several papers on the plants of New Zealand; and the species is named after Mr. A. McKay, Geologist to the Government of New Zealand.

Stirtonia, gen. nov.

Capsule oblong, with a narrow struma. *Operculum* oblique, conico-rostrate. *Peristome* none. *Calyptra* mitriform.

S. mackayi, sp. nov. Plate XVI.

Plants annual, monœcious, growing in patches $\frac{1}{4}$ in.–$\frac{3}{8}$ in. high, simple or occasionally branched. *Leaves* distant, imbricating, spreading, flexuous, acicular from an erect sheathing-base; margins entire; nerve stout, occupying all the upper portion of the leaf. *Areola:* Upper small, dense; lower linear; leaves scarcely altered when dry. *Perichætial leaves* nearly erect, acicular from a large erect sheathing convolute base. *Fruit* acrocarpous. *Fruitstalk* nearly erect, pale, slender, $\frac{3}{8}$ in. long. *Capsule* oblong-clavate, with a narrow solid tapering struma. *Operculum* oblique, conico-rostrate, slender, one-third the length of the capsule. *Peristome* none. *Calyptra* mitriform, laciniated at the base, half the length of the capsule.

Hab. On wet turfy soil, Stewart Island; June, 1889, and January, 1892. Collected by R. B.

EXPLANATION OF PLATE XVI.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial leaves.
4. Upper leaf.
5. Middle leaves.
6. Calyptra.

Art. XX.—*On the Vegetative Organs of* Haastia pulvinaris.*

By Miss E. Low, B.A.

Communicated by Professor A. Dendy, D.Sc.

[*Read before the Philosophical Institute of Canterbury, 2nd August, 1899.*]

Plates XVII.–XIX.

1. Introduction.

The reasons why this plant has been taken as a subject for research are twofold. In the first place, it is of great interest, being a remarkable instance of adaptation to alpine environment; and, in the second place, it has never before been more than barely described. The only literature to be found on the subject is Hooker's description of it in his New Zealand Flora, and he describes it as "forming dense hemispheres or cushions, 3 ft. across, covered with fulvous wool, branches with the leaves on as thick as the thumb. Leaves patent, ½ in. long, crenulate, most densely imbricate, broadly obcuneate, with dilated, rounded tips, margins recurved towards the tip, membranous, 3-nerved when wool is removed. Heads ⅓ in. broad. One of the most extraordinary plants in the Islands."

As the flowers of *Haastia* (order *Compositæ*) are of no particular interest, and differ to no marked degree from those of other gnaphalioid *Compositæ*, only the vegetative organs of this plant have been made a subject of research.

2. External Characters.

All the plants of the genus *Haastia* are very peculiar woolly herbs, and some have received, together with certain species of *Raoulia*, the suggestive popular name of "vegetable sheep"; but of all *H. pulvinaris* is at once the rarest and the most remarkable, and is larger and of denser growth than the other species. It is perennial, low-growing, rounded, and as large as an ordinary sofa; of the shape of a flattish cushion, and of a light green-grey colour. The woolly, com-

* This research was carried out in the biological laboratory of the Canterbury College, and formed the subject of a thesis for the honours degree of the New Zealand University. The thesis was first prepared in 1897, but the manuscript and drawings were lost in the wreck of the "Mataura," so that the thesis had to be rewritten and fresh drawings made in 1898. Since it was completed I learn that Dr. W. V. Lazniewski has published a description of the leaves of *Haastia pulvinaris* in a memoir which Miss Low had no opportunity of consulting ("Beiträge zur Biologie der Alpenpflanzen": Flora, 1896, 82 bd., heft. iii.).—A.D.

pact branches, with their round, flat tops, are all of the same height, and are all so closely packed together "that the point of a pencil," or even of a pin, cannot be thrust down between them (fig I.). The older branches reach a diameter of $\frac{1}{4}$ in.–$\frac{1}{3}$ in., but as they are coated down to the ground with old leaves they appear to have a much greater diameter. The stem is of a brownish colour, with bark.

The *branch system* is a polychasium (fig. II.). The main axis gives rise either to one or two lateral branches which keep pace with it, and they themselves send out one or two lateral branches, which likewise reach the same height. In this way no one branch exceeds the rest in height, and the surface is flattened. As all the branches are short, the result is an extremely compact mass.

In the *leaves* of *Haastia* lies its great peculiarity (fig. XI., A, B). They are, as Hooker describes them, "patent, with dilated, rounded tips, margins recurved towards the tip." The leaf is sessile, with a fairly broad base, the lower part of the leaf membranous and colourless, while the recurved, upper portion is thick and of a bright-green. But it is in the presence of the characteristic "wool" that the leaf is, perhaps, most peculiar. This consists of vast numbers of long and slender hairs, which grow from all parts of its surface, except on the lower part of its inner surface, which part closely embraces the stem. The recurved tip is the most densely covered with wool.

Arrangement of leaves: The divergence is two-fifths. Although the leaves are so closely packed together on the stem and cannot be distinguished from each other when the branch is intact, yet the divergence two-fifths appears to be kept very regular throughout.

The *root* is of about the same thickness as the stem, is much branched, and has a brown, barky appearance. The tap-root is extremely rigid, is clothed in bark, and is several feet in length.

3. Minute Anatomy.

Stem.

The structure of the young stem is marked by a circular or elliptic resin-passage in the cortex, opposite each vascular bundle (fig. III.), surrounded by a secreting layer of cells, smaller than those of the cortex, and sometimes having granular contents. The vascular bundles have the ordinary structure of open, collateral bundles, and are, at this stage, quite distinct and separated by ground parenchyma, although cambium is beginning to appear between them. The epidermal tissue is very slightly cuticularised, and underneath it is

the ordinary cortex of ground parenchyma; the pith consists of large, thin-walled cells.

In an older stem, of a year's growth, there is a development of cork, rectangular cells arranged regularly in rows, with brown walls slightly thickened arising from the phellogen layer (fig. IV., *ph.*). At irregular intervals the cork splits, and leaves crevices through its whole thickness. There are no lenticels of the ordinary form. The cortex is a fairly wide band of colourless, thin-walled cells, more or less circular; they contain no starch, and no visible contents other than a clearly defined nucleus. The resin-passage, abutting on the phloëm, is very well marked, and is surrounded by small cells with granular contents and thin walls. The process of their formation is seen to be this: A large granular cell, bordering on the vascular cylinder, divides, and the daughter cells divide again, the result being four granular cells, which go on dividing, and tend to separate round an elliptic cavity (fig. IV., A, B, C, D).

The phloëm of the young stem is seen to consist wholly of thin-walled elements, sieve-tubes, companion-cells, and parenchyma; but at this stage sclerenchyma appears in masses at its outer edge, beneath the resin-passages (fig. IV., *scl.*), with very narrow lumina.

At first two or three cells immediately interior to the cavity appear to have slightly thickened walls. These gradually become thicker and thicker, and the neighbouring cells show the same process; and when it is complete they form an elliptic mass of an indefinite number of cells. When separated from the surrounding tissue, they are seen to be of the same size and form as the cells of the phloëm parenchyma, and their thick walls are slightly pitted.

The sieve-tubes, with their granular contents, and accompanied by companion-cells, are found only in the inner portion of the phloëm; the outer portion consists of large-celled phloëm parenchyma, thin-walled, elongated, with rounded ends closely dove-tailing.

The medullary rays in the phloëm are much like the parenchymatous cells, and are several cells wide (fig. IV., *m.r.*).

The cambium consists, as usual, of a layer of thin-walled, rectangular cells. In this stage interfascicular cambium has appeared between the bundles, forming a closed ring of vascular tissue; but the primary medullary rays still consist of several layers of cells, which are slightly thickened, with pitted walls (fig. V., B), in the xylem; the cells are longitudinally elongated, with square ends.

The xylem consists of vessels, tracheides, and fibres. The secondary vessels have wider lumina than the other cells;

wood fibres comprise a large portion of the xylem, while tracheides also are numerous.

The various forms of tissue in the wood are all pitted, except the spiral vessels at the inner edge of the bundle. The fibres are thick-walled, with tapering ends, and only slightly pitted. The tracheides are not so long, have thinner walls, are more densely pitted. The vessels when mature are large, and very densely pitted.

The pith consists of large, circular cells closely packed together, with slightly thickened, pitted walls.

A stem still older (fig. VI.) shows a broader band of cork, with the same radial chinks. The cortex remains the same, with its resin-passages, but is afterwards disorganized by the formation of successively deeper bands of cork. But the sclerenchyma, which was originally near the resin-passage, now appears sunk deeply in the phloëm parenchyma, and is in large masses.

The xylem has undergone the ordinary changes of woody stems, and consists wholly of thick-walled elements. The vessels, which are not very numerous, are strongly marked by their wide cavities. Tracheides are numerous, but the great mass of the wood is made up of wood fibres. At this stage the cells of the medullary ray are thickened.

Root.

The young root shows externally a small-celled layer of cells, bearing root-hairs—the piliferous layer (fig. VII.). Beneath it is a layer of large, polygonal cells, with their radial walls slightly thickened—the exodermis. The cortex is of flattened cells loosely packed, and forms a wide band of tissue. The vascular cylinder is irregularly four-cornered. There are, at first, four alternating bundles of xylem and of phloëm; but at this stage a formation of secondary wood and of secondary bast has taken place. The primary elements are still visible, especially those of the wood. The primary xylem consists of four masses of vessels, each occupying a corner of the cylinder. The narrow vessels situated at the outside of each mass are the spiral vessels, while the large pitted vessels radiate towards the centre, and have rather thinner walls. These do not quite meet at the centre of the cylinder, and there is a considerable development of ground tissue, with thin walls. Outside this central mass is a thin band of secondary xylem, of thin-walled cells, of rectangular shape, arranged in rows, developed especially opposite the primary phloëm bundles. The cambium-ring is fully formed, and is forming the secondary phloëm, irregular, thin-walled cells. The primary phloëm is still visible.

In an older root the outer layers of cells become strongly

cuticularised (fig. IX.), but there appears to be no formation of phellogen. The cortex is here modified, and in its inner layers appear spaces, crossed by bands of cells. These spaces, like those of the stem, contain resin; but their formation is less regular. They are formed by the separation of the cells of the cortex, with less regular divisions. The form of the vascular cylinder is rounded at this stage. The phloëm-band is regular and broad, the outer layers consisting almost entirely of parenchyma and sclerenchymatous cells with greatly thickened, pitted walls. The xylem consists wholly of thick-walled elements, as in the older stem. The pith, too, has thickened, pitted walls (fig. X.). In a still older root there is no phellogen, and no regular formation of cork; but the cells of the cortex become cuticularised in a centripetal direction. This process continues into the outer cells of the phloëm layer, the cortex with its resin-passages peeling off as bark. The outer layers of phloëm consist, in large part, of masses of sclerenchyma, and these extend deeply into the tissue of the phloëm.

Leaf.

The leaf is $\frac{1}{3}$ in.–$\frac{1}{2}$ in. in length. The tip is as broad as the leaf is long, tapering towards the base (fig. IX., A, B). At its base it is thin and membranous, at its tip thick and fleshy. Into each leaf there enter three vascular bundles, or sometimes four (fig. III.), closely resembling those of the stem, except that they are closed; they are accompanied by a resin-passage, continuous with those in the stem (fig. III.). Near the base the leaf is composed of a compact tissue of cells, rounded in form and colourless, with the exception of a single layer of cells on the under-surface next the epidermis, which contain a few chlorophyll grains. Around the bundle there is a layer of cells similar to those of the mesophyll, but smaller. The epidermis of the lower surface contains a few stomata (fig. XII., *st.*). The cuticle is only slightly developed, and some of the epidermal cells on the under-surface are observed to grow out into long, multicellular hairs.

Towards the base of the leaf the three bundles branch once or twice, but when they reach the fleshy green tip they break up into a close network. In this fleshy tip lies the greatest peculiarity of the plant. Stripped of hairs and examined on the upper side it exhibits a great number of projections of tissue (fig. XI., E). On the lower side (F) it has corresponding depressions in its surface, so the projections are of the nature of bags of tissue.

This part of the leaf has a very slightly cuticularised epidermis, with many stomata on the upper and under surfaces. The mesophyll has the cells of the upper surface

arranged at right angles to the surface, but they are not of the usual palisade form, being more rounded. Instead of the spongy parenchyma there are only one or two layers of cells bordering on the epidermis, and the rest of the space is occupied only by air.

The vascular bundles have the same conformation in the tip as in the base, and each is still accompanied by a resin-passage. Towards the tip the bundles are small, the spiral elements being most noticeable. There is a close network of them, one entering each projection, and one lying between each two adjacent projections.

The hairs on the leaves are of interest; they occur only where needed for protection—that is, on the lower and outer surface of the base and on both surfaces of the tip. They are multicellular, and each springs from a single epidermal cell. The young hair is composed of only a few cells, each with abundant protoplasm and nucleus. The terminal cell is larger than the rest, and forms an enlarged, rounded tip. It is densely filled with protoplasm, and cuts off new cells from its base (fig. XIII., *h*), so that in time it comes to consist of from ten to twelve cells, or even more. All the cells, except three or four at the base, increase greatly in length; their walls are cuticularised, and the tip becomes pointed. The basal cells sometimes retain a nucleus and remains of protoplasmic matter, but the rest of the cells entirely lose all trace of nucleus and protoplasmic matter. The basal cells are intimately connected, but the longer cells are only loosely jointed together; their tips, which are pointed and covered with pits, in many cases slide past each other, cohering very loosely (fig. XIII., B). In some cases peculiar double hairs are formed (fig. XIII., C).

4. Habitat and Relation to Environment.

Haastia pulvinaris is an alpine plant, inhabiting the mountains of South Nelson, at an altitude of from 5,000 ft. to 6,000 ft. The conditions under which it grows are these: It lives on those shingle-slips that are such a characteristic feature of the eastern side of the New Zealand Alps. They are composed of loose, dry shingle, and their conformation is being continually altered by the slippery nature of the shingle. The upper layers of the shingle are dry, and in summer are burning hot, but the lower layers are wet, and supplied with a never-failing supply of water.

Situated as it is, the foes from which *Haastia* has most to fear are the physical conditions of its environment, the extremes of temperature, the violent wind-storms at all seasons of the year, and the total want of any kind of shelter. The plant has adapted itself so as to be able to resist these in-

jurious influences. In consequence of its altitude, and the lack of shelter, the worst foe of *Haastia* is the intense cold of winter. Its adaptations to secure protection from the cold are remarkable and very obvious. The whole structure is such as to diminish radiation, and to keep out icy wind and snow-water. It is low-growing, very compact by reason of its method of branching, and forms a rigid mass which is impenetrable both from the sides and the top. Each branch is covered with leaves adpressed to the stem, closely packed together, which persist on the stem a great length of time, forming a covering for the plant down to the ground. Little heat is lost, too, by radiation from the leaves, for these are reduced considerably in size and overlap each other, so that no part is exposed but the tip. Each leaf, too, is covered, in parts that would else be exposed, by a very dense wool, which, as a non-conductor, is as well fitted as sheep's wool for retention of heat. By these means neither stem nor leaf is free to radiate heat. The adaptations that keep the plant warm in winter serve to prevent excess of heat in summer: the non-conducting wool prevents the plant-tissue from being scorched up in this arid situation, as also excessive loss of water by transpiration.

The mountain wind-storm is another great foe. The wind, sweeping down the mountain-sides, finds on the desolate slips nothing to check its fury, therefore in winter there is the storm-wind and in summer the fiery north-wester. The plant is helped to contend against these foes by its low-growing habit and the stoutness of its stem, due chiefly to the large development of sclerenchyma; and it is so compact that no wind can enter it to damage its branches.

Haastia pulvinaris has no need to fear what would be to other plants a formidable foe—the shifting of the shingle. Its root is strong owing to sclerenchyma; and the combined strength of the branches is so great that they can withstand the injurious influences of heavy masses of shingle.

Haastia pulvinaris would be exposed to drought in summer did it not send down a long tap-root, which is also of advantage in firmly fixing the plant in the shingle.

The adaptations of the plant to prevent loss of heat, the closeness and rigidity of the cushion, the closely adpressed, hair-covered nature of the leaves, are equally active in preventing assimilation, transpiration, and respiration. Yet the leaves, though tightly packed and warmly clad, have still means of performing these functions. Whereas the lower part of the leaf is closely pressed to the stem on its inner surface, and is covered by other leaves on its outer surface, the leaf-tip is free, and is modified for the better performance of the leaf-functions.

As has been before noted, the tip of each leaf is covered with bag-like projections of tissue; these greatly increase the assimilatory and respiratory surface without increasing the size of the leaf. All the cells of the mesophyll contain abundant chlorophyll, and both the upper and the under surfaces of the tip are well calculated to perform the leaf-functions, for stomata are very plentiful, and the cuticle is extremely thin. The large air-space in the mesophyll of the tip is also helpful in the aeration of the tissues.

Thus *Haastia* is developed in two distinct ways—Firstly, for protection against climatic rigours; and, secondly, for the performance of those vital functions that were threatened by the first set of modifications.

EXPLANATION OF PLATES XVII.-XIX.

Plate XVII.

A piece of *Haastia pulvinaris*, from above and from below.

Plates XVIII. and XIX.

Fig. I. A piece of *Haastia pulvinaris*; natural size.
a, stem stripped of leaves.

Fig. II. Diagram showing branch system.

Fig. III. Cross-section of young stem, with leaf-base
e., epidermis; *c.*, cortex; *r.p.*, resin-passage.

Fig. IV. Section of year-old stem.
phel., phellogen; *f.*, fissure in cork; *scl.*, sclerenchyma; *s.t.*, sieve-tubes; *c.*, cambium; *v.*, wood-vessel; *w.f.*, fibre; *m.r.*, medullary ray; *s.v.*, spiral vessel.

Fig. IV. A, B, C, D, stages in formation of resin-passage.

Fig. V. Longitudinal section of year-old stem.

Fig. V. A, sclerenchyma found in phloëm; B, medullary ray, longitudinally elongated, pitted; C*f*, wood-fibre; *tr.*, tracheide; *p.v.*, pitted vessel; *s.v.*, spiral vessel.

Fig. VI. Transverse section of older stem.

Fig. VII. Transverse section of young root.
a, piliferous layer; *r.h.*, root-hair; *pp.*, protophloëm; *2nd ph.*, secondary phloëm; *c.*, cambium; *2nd x.*, secondary xylem; *1st x.*, primary xylem; *x.v.*, vessel.

Fig. VIII. Longitudinal section of same.

Fig. IX. Transverse section of older root.

Fig. X. Longitudinal section of same.

Fig. XI. A, B, leaf; natural size.
A, upper surface; B, lower surface; C, A enlarged; D, B enlarged; E, C stripped of hairs; F, D stripped of hairs; *p.*, projections.

Fig. XII. Section of base of leaf.
v, upper surface; *d*, lower surface; *p.*, phloëm; *x.*, xylem; *st.*, stoma; *c.l.*, chlorophyll layer; *b.*, base of hair.

Fig. XIII. Longitudinal section of open leaf.
a, terminal point; *h*, young hair; *st.*, stoma; *a.c.*, air-cavity; *r p.*, resin-passage of a bundle of network cut transversely; *sp.v.*, spiral vessel, seen longitudinally.

Fig. XIII. A_1, A_2, epidermis with stomata.
B, hair; *b.*, small-celled base, with nucleus in each cell, *n.* The other cells have pitted, pointed ends.

III.—GEOLOGY.

Art. XXI.—*The Geological History of New Zealand.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Otago Institute, 10th October, 1899.*]

If I were to ask you the question, "Why does every civilised Government establish a geological survey?" I expect you would answer, "To develope the mineral resources of the country." This no doubt is true, but I wish to point out that any geological survey which makes the discovery of economic minerals its primary object is sure to be a failure. That is, if its attention is directed to special details, it can never ascertain the true geological structure of the whole country; while it is necessary to know the geological structure and history of a large district before a satisfactory opinion can be given on the mineral capabilities of any particular locality. But the geological history of a large district cannot be learnt without extending the survey through the whole of it, and into parts of the country in which there are no minerals, for one part of the history will be learnt in one place, and another part in another place; so that it is only by an extended and systematic survey that the whole history can be put together. And I repeat that until the geological history of a district is known the opinion of a trained geologist on its economic resources can be of no more value than that of any experienced miner.

It follows, therefore, that the primary and fundamental object of a geological survey is to make a systematic investigation into the structure and palæontology of the whole country in sufficient detail for its geological history to be ascertained with considerable accuracy. The contrary system, of examining local mineral deposits first, is very much like marking out allotments and sections for sale on a map without having previously connected them by triangulation, in which case we all know the result will be confusion. It is the same with a geological survey; and we must remember that of the two parts into which it is divided—the general survey and the subsequent examination of special districts—the first is beyond private enterprise, because no individual has the time, the means, and the inclination to make a systematic investigation

of a large country and publish results; while, after the general survey is made, private individuals can easily undertake the local examinations, and may often be paid for doing so. Consequently it is the duty of the Government to take in hand an important work which cannot be done by private enterprise, and this is what most Governments of civilised countries have actually done.

Now, no systematic geological survey has yet been made of New Zealand—that is, there has been no close and continuous examination of the rocks, starting from a few localities and gradually spreading over the whole country. Nevertheless, in the intervals between the examination of mines and mining districts Sir James Hector has managed to get a sketch-map made of the greater part of the country, while some important districts have been examined more in detail. We thus know a good deal about the general geological structure of New Zealand although we do not know it accurately; and, as a consequence, in several cases the evidence appears to be conflicting, so that different opinions may be maintained according to the observer's interpretation of the evidence.

But while something has been done towards unravelling the geological structure of New Zealand, the palæontology has been woefully neglected. Large collections of fossils have been made by the survey, but they remain undescribed —most of them, indeed, as yet unpacked—in the Museum at Wellington, and there appears to be no chance of getting them described. According to the last annual report, there are more than thirty thousand specimens in the exhibition-cases, by far the larger part of which are unnamed and undescribed; while, in addition, there are about five hundred boxes still unpacked, many of which have been stored away for years. A slight attempt was made in 1873 to describe the Tertiary shells and Echinoderms; but the plates which were prepared to accompany the text have never been published. Also, in 1880 a report appeared on the Neozoic corals and Bryozoa, but nothing further has been done by the New Zealand Government. Nearly all we know of the palæontology of New Zealand is either due to the publication by the Government of Austria of the fossils collected by Dr. von Hochstetter in 1859, or is the result of private enterprise. The collections of the survey—made with great labour and at considerable expense—are wasted by the apathy of the Government, which appears not to know how great would be their scientific value if described and figured, and how useless they are as they now exist in the Museum at Wellington. It is a great pity that this should be so, for the geographical position of New Zealand gives to its geology a world-wide interest. It is in New Zealand alone that we

have any record of the ancient faunas and floras that successively overspread the South Pacific, and it is here that we must look for the principal evidence of the changes that have taken place in the physical geography and climate of this enormous area. Situated at the antipodes of Europe, any change of climate there brought about by the shifting of position in the axis of the earth, or by a change in the eccentricity of its orbit, or by a change in the obliquity of the ecliptic, or by any cosmical change whatsoever, must find its parallel here, and, consequently, New Zealand is to Europe a base of verification for all such-like hypotheses.

With our present imperfect knowledge it is not surprising that there should be several portions of the geological history of New Zealand on which differences of opinion are held. And I wish at the outset to make it clear that I am about to state my own opinions only, which I do not for a moment suppose are always correct. Geology at its best is an uncertain science, depending largely on the accuracy with which gaps in the series of facts are filled up by theory, and in our knowledge of the geology of New Zealand there are many and wide gaps. A more detailed and more systematic investigation might, no doubt, make me alter several of the opinions I am going to express. Nevertheless, I think that all the geologists who have examined New Zealand are pretty well agreed upon most points of its geological history. It is only on a few questions that we differ, and we may at least claim to have made the path of investigation easier for those who come after us. With this preliminary qualification, I will now proceed with my subject.

GENERAL GEOLOGICAL STRUCTURE.

A chain of mountains runs through the South Island from Otago to Nelson, narrow in Westland—where it is called the Southern Alps—but spreading out both in the north and in the south into several ranges. This mountain-range, or orographic axis, however, does not form the tectonic, or structural, axis of the Island—that is, it is not the central line of elevation of the mountains. This line, which is called the "structural axis," lies at their western base along the line of granites in Westland and Nelson; so that the mountain-range is only the eastern half of a huge geanticlinical arrangement of contorted rocks, the western half having been washed away by the heavy rains which fall upon that side, and which must have fallen for a very long time to have produced so great an effect. As these rains are due to the westerly winds sweeping over a large ocean, we have here a proof that moisture-laden westerly winds have predominated in these latitudes for a very long time.

All the sedimentary rocks up to the Hokanui system (Lower Jurassic) inclusive partake of the flexures in the mountains; while those of the Waipara system (Upper Cretaceous) are also involved to some extent in Otago and Nelson. But the rocks of the Oamaru (Oligocene) and younger series either retain their original plane of deposition or are occasionally distorted locally.

In the North Island the structural axis appears to be continued through the centre of the Island from Wanganui to the Bay of Plenty, and the chief mountain-range lies to the west of it, as in the South Island. This main range is formed by rocks belonging to the Maitai (Permo-carboniferous) and Hokanui systems, smothered on each side by Tertiary beds through which isolated ridges and peaks of the older Maitais and Hokanuis rise at intervals throughout the Auckland Province.

To the south-east of the main range in both Islands volcanic rocks occupy but a small area; but on the north-western side, from the centre of the North Island to Auckland, they cover more than half the country, and appear again in great force further north, between Hokianga and the Bay of Islands.

Wanaka System.

The oldest rocks in New Zealand are the crystalline schists of Central Otago, which have been called the "Wanaka system."* They are largely developed in the interior of Otago from the Taieri to the great lakes, and from thence they pass north, in a narrow band, at the western foot of the New Zealand Alps, as far as the Spencer Mountains, in the Nelson Provincial District. In Otago they appear to have the enormous thickness of not less than 100,000 ft., or about nineteen miles. The lower part of the system is formed principally of mica-schists, varying from coarsely foliated rocks with thick lenticular plates of quartz to finely foliated, with nearly parallel foliæ. These pass upwards into fine-grained mica-schists, silky phyllites, clay-slates, and quartzites.

Similar schistose rocks appear in Queen Charlotte Sound and the Pelorus; also in Collingwood County, at the mouths of the Aorere and Parapara Rivers. But each of these districts is separated from the main body of schists in Otago and Westland by younger rocks, which cross the Upper Buller from the Spencer Mountains to the Wangapeka River, and which hide the older schists. One of these detached portions —that near the mouth of the Aorere River—is overlain, appa-

* "Report on the Geology and Goldfields of Otago," p. 29; Hutton and Ulrich, Dunedin, 1875.

rently unconformably, by slate rocks containing graptolites of Ordovician age, and this is the only stratigraphical evidence we have as to the age of the schists; but we find in the rocks themselves other evidence of their great age.

In Central and Eastern Otago, away from the main range, these schists are not contorted, but lie at low angles—usually from 15° to 45°—so that the schistose structure cannot have been caused by lateral pressure. Neither can it be due to contact with large masses of igneous rocks, for there is a remarkable absence of those rocks throughout the whole area, the only eruptive rocks as yet described being the chlorite schists near Queenstown. We are therefore driven to the conclusion that the schistose structure is an original one, caused by the interior heat of the earth at a time when it was much greater than at present; and so we are constrained to class the rocks of the Wanaka system as pre-Cambrian.* An additional argument may perhaps be found in the large quantities of graphite and graphite-schist which occur occasionally in some of the older strata, for the occurrence of graphite is characteristic of Laurentian and Huronian rocks. The Wanaka system contains the gold-bearing rocks of Otago.

Takaka System.

The rocks of the next overlying system, called the "Takaka system,"† are found chiefly in the valley of the Aorere River, in Collingwood County; but also in two detached localities—one in the basin of the Baton River (a branch of the Motueka), the other near Reefton. Their united thickness has been estimated by Sir James Hector at between 15,000 ft. and 18,000 ft., but they cover a comparatively small portion of the country.

The lower, or Aorere, series consists chiefly of blue slates with beds of feldspathic and quartzose schist, the former containing graptolites belonging to the genera *Didymograptus*, *Tetragraptus*, *Dichograptus*, and *Phyllograptus*, and is no doubt of Ordovician age. The Baton River and Reefton series consist of slates and sandstones with calcareous beds, sometimes pure limestone. These calcareous rocks contain Trilobites and a number of Brachiopods, as well as a few Mollusca and corals, which appear to be of Siluro-devonian age. In Collingwood County gold reefs are found in rocks belonging to the Aorere series.

Maitai System.

The next rock-system consists of a large mass of sandstones and uncleaved argillites, with occasional beds of lime-

* Trans. N.Z. Inst., vol. xxiv., p. 361.
† Quart. Journ. Geol. Soc. Lond., vol. 41, p. 194 (1885).

stone, which in north-west Nelson and near Reefton lie quite unconformably on the edges of the folded rocks of the Takaka system. It has been called the "Maitai system" from the Maitai River at Nelson, although it is doubtful whether the rocks of the lower part of the Maitai Valley belong to it.* This Maitai system is very largely developed in New Zealand. In Otago, Canterbury, and Marlborough it lies directly on the Wanaka system; and it forms the greater part of the mountain-ranges of New Zealand in both Islands, from the Takitimos in Southland to the eastern side of the Bay of Plenty. It is again found in isolated patches on the north-west of Lake Taupo, and in many other places as far as the North Cape. In the North Island these are the oldest known rocks. The thickness of the system in the South Island is estimated by Sir James Hector at from 7,000 ft. to 10,000 ft.; but it is very difficult to form an opinion, as the rocks are everywhere highly folded and the stratification is often obscure.

Only three species of Brachiopoda have been found, all of which—if they have been correctly named—are also found in the Permo-carboniferous of Tasmania, and one of them—*Productus brachythærus*—seems to be characteristic of that formation in eastern Australia. Straight but slightly tapering tubes up to 2 in. or 3 in. in length and from $\frac{1}{10}$ in. to $\frac{1}{4}$ in. in diameter have also been found in several places in Canterbury as well as near Wellington. They are generally called "annelid tubes," but more probably they are the shells of pelagic Cephalopoda. The so-called annelid-beds, which contain these fossils, appear to belong to the upper part of the Maitai system, and on the western side of Lake Ohau they have been found together with the remains of plants.†

In several localities in both Islands red-jasperoid slates occur, sometimes associated with manganese-oxide, and this, together with the paucity of fossils and the general absence of plant-remains, points perhaps to a deep-sea origin.‡ It seems probable that these beds accumulated in the deeper portions of a sea, the more western and shallower portions of which were at the same time receiving the *débris* from a Permo-carboniferous Australian Continent.

In New Zealand the period closed with an eruption of granite, which is now found at intervals from Stewart Island, through Westland, to near Separation Point in Blind Bay. This granite has penetrated the rocks of the Maitai system, and is found as rolled fragments in the conglomerates of the

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* Quart. Journ. Geol. Soc. Lond., vol. 41, p. 201.

† McKay: "Reports of Geological Explorations," 1881, p. 79.

‡ Red slates are said to overlie rocks containing *Tæniopteris* in the Kaikoura Mountains (McKay: "Geological Reports," 1885, pp. 55–57). Possibly this may be due to inversion.

next system. It is in the rocks of the Maitai system, in the neighbourhood of the granites, that the gold reefs of Preservation Inlet and the Inangahua occur.

Hokanui System.

The next system is better developed in the Hokanui Mountains of Southland than elsewhere, and so it has been called the "Hokanui system." In the southern part of Otago it covers a considerable amount of country, from the Livingstone Mountains to the sea between the mouths of the Mataura and Clutha Rivers, where it is between 20,000 ft. and 25,000 ft. thick. In Canterbury it is known in many places, from Mount Potts and the Malvern Hills to the Upper Wairau and Kaikoura Mountains. It is also developed at Wairoa and Richmond, near Nelson, but it is doubtful whether it exists on the west coast of the South Island.

In the North Island the Hokanui system occurs at Wellington and along the eastern side of the Ruahine Mountains to the Ruakamara Mountains, near the East Cape, always lying on the south-eastern side of the Maitai system. On the west coast of the North Island it is found at Kawhia, Raglan, and Port Waikato, and here it lies on the north-western side of the Maitais. This seems to show that the geanticlinal axis of the South Island runs through the centre of the North Island from Wanganui to the Bay of Plenty, although no Palæozoic rocks are visible, and it is not even a mountain-range, but only a band of volcanic activity.

There is, no doubt, a stratigraphical break between the Hokanui and Maitai systems, but in no place is the former seen to rest on rocks older than the Maitais, and the boundary between the two systems is very difficult to draw.

Near the junction of the Hokanuis with the Maitais thick beds of greenstone-ash (known as the "Te Anau series") are found, often accompanied by intrusive basic rocks, and it is sometimes uncertain to which system they should be referred. Indeed, they may belong to more than one geological horizon. They are probably connected with the outbursts of basic and ultra-basic eruptive rocks which are found from Bluff Hill in Southland to Nelson. These rocks in the West Coast Sounds are chiefly gabbros and diorites which have acquired a foliated structure through pressure subsequent to their eruption; and the same kinds of rocks are found in the Upper Buller and in the Riwaka Mountains, west of Blind Bay. Hurunui Peak, in North Canterbury, is another dioritic volcano belonging to the lower part of the Hokanui system. Ultra-basic rocks (peridotites and serpentines) are found at intervals from Milford Sound to D'Urville Island, and these also appear to belong to the same period as the diorites.

The sedimentary rocks are blue mud-stones, with greenish or brown sandstones and occasional beds of conglomerate. Granitic conglomerates are commonly found in Southland in the Upper, or Mataura, series; and Mr. S. H. Cox says that he has found them at the base of the Lower, or Wairoa, series, in conjunction with beds of greenstone-ash and breccias, thus showing that the granites are older than some of the basic rocks.

Remains of plants are found all through the system, and in the upper part thin seams of coal often occur. The most characteristic plants are *Pterophyllum*, *Podozamites*, *Thinnfeldia*, *Tæniopteris*, and *Polypodium*. Fossil animals are also tolerably abundant, and include *Ammonites*, *Belemnites*, *Trigonia*, *Edmondia*, *Monotis*, *Trigonotreta*, *Spirifirina*, and *Athyris*. Also a single vertebral centrum, belonging probably to *Ichthyosaurus*, has been described by Sir James Hector; and teeth, apparently belonging to a Labyrinthodont, have been found near the Nuggets, in Otago, and also in the Wairoa district, near Nelson. These fossils are sufficient to prove that the rocks are of Lower Mesozoic age, and probably they are the equivalents of the Trias-jura formation of eastern Australia.

Inferences from the Facts.

We now come to a great break in the geological history of New Zealand, and this enables me to pause in my narration of facts and see what we have already learnt before going on to the second part of the history. Our oldest rocks—those of the Wanaka system—are undoubtedly the products of the denudation of a land-surface, but where that land lay we cannot tell. We are also quite as ignorant of what was taking place in our part of the world during the older Palæozoic era, further than that the fossils of the Siluro-devonian rocks seem to imply a shallower sea than that which prevailed in the Ordovician period.

The next fact we have is that, after the deposition of the Siluro-devonian rocks, a synclinal trough was formed in north-west Nelson and Westland, to the west of the present main axis. Denudation followed, by means of which the Takaka rocks were completely removed, except those preserved by the syncline. This implies the existence of a land-surface in our area during the late Devonian or early Carboniferous. It is possible that these movements took place in the middle of the Devonian period in connection with similar ones which at that time occurred in Australia; and, if such is the case, land probably existed in the Upper Devonian in both the Australian and New Zealand areas, so that they may have been connected and formed part of a continent. But we have in New

Zealand no land plants or animals of the period by which we could test the truth of this hypothesis.

The land then sank and the Maitai system was deposited. Towards the end of the Carboniferous period the New Zealand area appears to have been under a deep ocean, but with shallower water to the west and north-west, for in Tasmania and Australia we find that the rocks, which were probably contemporaneous with our Maitai system, contain shallow-water beds with plant remains; while in New Zealand there is an absence of conglomerates and of fossils generally. Perhaps, also, we have direct evidence of deep-water conditions in our deposits of manganese-ore and red-jasperoid slates.

Probably it was early in the Permian period when elevation, with folding of the rocks, again took place; and this was accompanied by the intrusion of granite in the South Island along the axis of the present New Zealand Alps. After a long interval the granite was followed by a series of basic volcanic eruptions, and the land began slowly to sink, and this was continued during the Triassic and the first half of the Jurassic periods. During the whole of this long-continued subsidence—while the rocks of the Hokanui system were being laid down—land must have been in the close neighbourhood, for in the rocks we find bands of conglomerates and abundant vegetable remains.

The sedimentary rocks of the Hokanui system have much the same lithological characters throughout New Zealand, and appear to have been chiefly the products of large rivers which drained a continent, and not the products of small island streams; so that probably New Zealand was then placed near the coast-line of a large continent stretching away to the north and west. Whether this land reached to Tasmania and Australia we cannot say until the New Zealand fossils have been compared with those of Australia; but if it be true that a Labyrinthodont lived on the banks of these rivers a land-connection between Australia and New Zealand must have existed. Certainly there is no evidence that the Permo-triassic land was a mountainous region near New Zealand, for there are no signs of any deep local excavations having taken place, such as would have been produced by mountain streams, and no evidence has as yet been found of the presence of Permo-triassic glaciers.

About the middle of the Jurassic period folding of the rocks again occurred along the same north-east and south-west axis; the Alps were formed, and the present land of New Zealand may be said to have been born, for since then it has never been submerged. Up to the present we know of no igneous outbursts which accompanied this third folding. But some of the granites along the West Coast—such as that

between Waimangaroa and Denniston, near Westport—may ultimately prove to be of Jurassic age, for this granite differs from the others in the significant fact that the quartz shows no pressure granulation, while most of the other granites have been altered into gneissoid rocks by the pressure exerted when the sedimentary rocks were being folded.

In the period that followed the upheaval of the New Zealand Alps great denudation took place on the north-western side—the evidence for which will be given presently—and this must have been due to moist westerly winds producing heavy rains, as at present. We must therefore assume that the Tasman Sea was then in existence, and we have reason for supposing that it has been in existence ever since. The evidence for this is the absence of terrestrial mammalia and snakes from our present fauna, and the remarkable distinctness of our Cretaceous and Tertiary fossils from those of other countries. But New Zealand was not at first so small as it is now. Not only did it spread more to the west, but it seems to have extended north to New Caledonia; and, very probably, it was attached to New Guinea, from whence it drew the more ancient elements of its present flora and fauna.

Waipara System.

Resuming now our history, we come next to rocks of Cretaceous—probably Upper Cretaceous—age, called the "Waipara system."* This is found on the eastern side of New Zealand, at the Shag Point coal-mines in Otago, and from the Malvern Hills in Canterbury to Cape Campbell. Crossing Cook Strait we find it again on the east coast of Wellington and in Hawke's Bay; and again, perhaps, from Poverty Bay to the East Cape. On the west coast of the South Island we have the coal measures of Greymouth and Westport, and also those of Pakawau, near Collingwood.† But on the west coast of the North Island Cretaceous rocks are known only in the valley of the Wairoa River, north of the Kaipara, and perhaps at Kawhia. However, we must remember that, as the fossils of the North Island have not yet been carefully compared with those from the South, it is impossible to feel certain about their age.

The strata are usually much disturbed, except in North Canterbury, and sometimes form mountains 5,000 ft. or 6,000 ft. in height. Also, they lie quite unconformably on the older rocks. In Canterbury and Marlborough they rest indifferently on the Hokanuis or on the Maitais, and at

* Under this name I include the Lower Greensand formation of Sir James Hector, as well as the lower part of his Cretaceo-tertiary formation.

† Trans. N.Z. Inst., vol. xxii., p. 377.

Pakawau they lie directly on the Takaka system. This shows that great denudation of the land had taken place between the time of the upheaval of the Hokanui and the deposition of the Waipara system.

During the formation of the older rocks of this system extensive eruptions of rhyolite took place along the western margin of the Canterbury Plains, and these were followed by dolerite and basalt. In Banks Peninsula we also find the oldest volcanic rocks to be rhyolite; and it is possible that the andesitic calderas of Lyttelton, Little River, and Akaroa may also belong to the Cretaceous period, although it is more probable that they are Tertiary. Many of the andesites of Banks Peninsula are peculiar from containing olivine, while the dykes cutting them are augite-trachytes.

At the Waipara River and at Amuri Bluff the sedimentary rocks contain *Trigonia, Inoceramus, Conchothyra*—a genus allied to *Pugnellus*—as well as *Belemnites* and *Ammonites;* also marine saurians belonging to the genera *Cimoliosaurus, Polycotylus*, and *Leiodon*, which are more nearly allied to the contemporaneous reptiles of North America than to those of Europe. *Ammonites* and *Scaphites* have also been found at Waipawa, near Napier; but none of these Cretaceous fossils are known from the west coast of the South Island. Of the plants, *Araucaria, Flabellaria*, and *Cinnamomum* may perhaps be taken as characteristic; but, according to Baron von Ettingshausen, there are also several genera which still live in New Zealand. These are *Panax, Loranthus, Hedycarya, Santalum, Fagus, Dammara, Podocarpus*, and *Dacrydium*, to which, on the authority of Mr. Buchanan, we may add *Aciphylla*. These probably formed part of the foundation of our present flora; and, if this be the case, land must have existed continuously in New Zealand from the Upper Cretaceous period to the present day. And, as the land stood higher in the Cretaceo-jurassic times, we may safely infer that since the middle of the Jurassic period New Zealand has never been altogether submerged beneath the sea.

Oligocene Period.

*Oamaru Series.**—The oldest Tertiary rocks in New Zealand are the coal measures of Kaitangata, Waikato, Whangarei, and other places. These were formed on land which, in the Oligocene period, sank below the sea, when they were

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* I here include the Ototara and Mawhera series of Sir James Hector's Cretaceo-tertiary formation, as well as his Upper Eocene formation, except the Mount Brown beds. My reasons for doing so will be found in the "Quarterly Journal of the Geological Society of London" (vol. 41, pp. 266 and 547); also in the "Transactions of the New Zealand Institute" (vol. xx., p. 261.)

covered by marine rocks, which culminated in a limestone, well known as a building-stone, in many parts of New Zealand. This stone, under various names, is found in patches all round the coasts of New Zealand, from Winton in the south to the Bay of Islands in the north, as well as in many of the inland valleys. It belongs to that variety called polyzoal limestone, because it is made up principally of small fragments of calcareous Polyzoa, &c.; and it is, no doubt, the remains of a reef which in the Oligocene period encircled New Zealand. These Tertiary rocks lie unconformably on those of the Waipara system at the Weka Pass, Mount Somers, and a few other places; but elsewhere they lie upon older rocks, belonging to the Hokanui and other systems. At the time of the formation of the Oamaru limestone there were living in our seas a Zeuglodont whale (*Kekenodon onamata*), as well as true cetaceans (*Squalodon serratus*), a penguin (*Palæeudyptes antarcticus*), the huge shark (*Carcharodon angustidens*), rays (*Trygon* and *Myliobatcs*), and a sparoid fish (*Sargus laticonus*), as well as the nautilus called *Aturia australis*. But with them are found some Cretaceous-looking Echinoderms belonging to the genus *Holaster*. These last were no doubt survivors from Mesozoic times, and I agree with Dr. Stache and Sir F. McCoy in thinking that the rocks in which they occur belong to the Oligocene period.* A species of *Unio* has been described from the coal-beds in Otago.

In the neighbourhood of Oamaru basic volcanic rocks underlie the marine beds, and in other places of Otago and Canterbury volcanic rocks are interbedded with the sedimentaries which belong to the earlier part of the Oamaru series. The most remarkable of these is a hydrated tachylyte, which is found in several places between Lookout Bluff, near Hampden, and Castle Hill, in the valley of the Waimakariri, a distance of a hundred and fifty miles.† The volcanic system of Dunedin probably belongs to the close of this period, as also do the volcanic rocks in the neighbourhood of Palmerston South, and those on the northern side of the Hurunui Plains at Culverden and Pahau, as well also as a large part of the volcanic rocks of Banks Peninsula. The older rocks in the Dunedin Peninsula are andesites, followed by olivine

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* Mr. G. F. Harris is also of opinion that they are younger than the Eocene of London, Paris, &c. (see "Catalogue Australasian Tertiary Mollusca in the British Museum," p. 15; 1897). In the Geological Magazine for 1891, vol. 7, page 491, Dr. T. W. Gregory quotes me as having once been of opinion that the Echinoderms belonged to Dr. Hector's Cretaceo-tertiary. This is a curious mistake, for my paper on the correlations of the Curiosity-shop beds was written to show that there was no Cretaceo-tertiary formation in New Zealand.

† Journ. Roy. Soc. of N.S.W., vol. xxiii., p. 152.

tephrites,* a rock not known from any other part of New Zealand.

Before going any further I should like to point out that each of our geological systems, from the Hokanui to the Oamaru, seems to have been ushered in by volcanic outbursts, which were followed by depression and subsequent elevation.

Miocene Period.

Pareora Series.†—Marine rocks of Miocene age, with from 20 to 65 per cent. of the fossil molluscs belonging to still living species, and with the teeth of the shark *Carcharodon megalodon*, are found in many parts of the New Zealand coasts; while in the interior they go up to a height of 3,000 ft. above the sea in the South Island, and to not less than 4,000 ft. in Hawke's Bay. In a few places—such as Pomahaka, Waihao, and Mokau River—they are underlain by beds of coal.

About 235 species of Mollusca have been described from the Pareora series, and eighty-four from the Oamaru series, and fifty-one of these species are common to both; so that both series are closely connected palæontologically. Nevertheless, the Pareora series very often lies unconformably on the Oamaru series, the latter having undergone considerable denudation before the former was deposited. Examples of this may be seen at Palmerston South, Oamaru, Elephant Hill, Kakahu, Greymouth, and Komiti Point, in the Kaipara; while at other places—*e.g.*, Southland, Waiau (in Amuri County), Hawke's Bay, and Kawau—the Pareora series rests upon Mesozoic or Palæozoic rocks. From this we infer that at the end of the Oligocene period the land was slightly elevated for a short time and then subsided to a lower level than before, New Zealand in the Miocene period being reduced to a group of islands.

The marine rocks are chiefly soft sandstones and clays, but limestones are largely developed on the east coast of the North Island from Wellington to Hawke's Bay.

The fossils are remarkable for the large size of the shells belonging to the genera *Ostrea*, *Pecten*, *Lima*, *Cucullæa*, *Crassatella*, *Cardium*, *Cytherea*, *Dentalium*, *Pleurotomaria*, *Turbo*, *Scalaria*, *Turritella*, and *Natica*, which give the fauna quite a tropical appearance. And this evidence is much strengthened by the fact that the fruit of palm-trees has been found not only at Mongonui in the north, but also when making the Livingstone Tunnel near Oamaru. Several of our

* Ulrich, Report Aust. Assoc. Adv. Science; Christchurch, 1891, p. 127.

† I include here the Waitemata series of Sir James Hector's Cretaceo-tertiary and the Mount Brown series of his Upper Eocene, as well as his Upper and Lower Miocene formations.

Miocene and Pliocene genera of Mollusca appeared first in Australia, and afterwards in New Zealand, showing that part of our Tertiary fauna reached us from Australia, and not from an antarctic continent. Nevertheless, out of the 268 species of Mollusca known from the Oamaru and Pareora series, only thirty-one, or 11½ per cent., are found in Australia, which is a less percentage than exists at the present time. So that our fauna was, even in the Miocene, very different from that of Australia. What is perhaps still more noticeable is that no less than thirteen species of our Miocene Mollusca are also found fossil in the Tertiary rocks of Patagonia, and of these only two are known in Australia. This shows some connection with Patagonia in which Australia did not share.

Another important fact connected with the Miocene period is the great outburst of volcanic energy in the North Island. In the South Island the only eruptive rocks we know to be of this age are the dolerites of Moeraki and Mount Charles in Otago, and those of Timaru and Mount Cookson near Waiau; to which may perhaps be added Mount Herbert in Banks Peninsula. These were the last expiring efforts of vulcanism in the South, and its energy now shifted to the North. The andesites of the Thames Goldfields,* as well as those of Whangarei Heads, Kaipara, and the Great Barrier Island, as also the trachytes of Hicks Bay,† date from the early part of this period. And as pumice is found in rocks of Miocene age at Hawke's Bay‡ it seems probable that part of the rhyolites and andesites which form the plateau extending from the southern side of Lake Taupo through Patatere to Te Aroha are of Lower Miocene age. At a slightly later date came the rhyolites forming the cliffs round Lake Taupo, which are remarkable for containing small crystals of hypersthene, by the presence of which the pumice of Taupo can be distinguished from that found elsewhere.

Pliocene Period.

The Wanganui series contains a number of marine fossils, of which from 75 to 93 per cent. of the shells and about 76 per cent. of the Polyzoa belong to still living species, so that we can safely consider it to be newer Pliocene. It lies unconformably on Miocene rocks at Napier, and it is doubtful whether we have in New Zealand any marine beds belonging to the older Pliocene. The Wanganui series is known only in the southern half of the North Island, from Patea and Wanganui on Cook Strait to the northern part of

* Report Aust. Assoc. Adv. Science, vol. i., p. 253; Sydney, 1887
† Cox, Reports Geol. Explor. for 1876–77, p. 112
‡ Hill, Trans. N.Z. Inst., vol. xx., p. 304.

Hawke's Bay.* However, it probably occurs also at Taranaki, Poverty Bay, and several other places in the North Island.

In the South Island the marine rocks of the north appear to be represented by thick beds of unfossiliferous gravels deposited by mountain torrents, some of which may date back to the close of the Miocene.

Of volcanic rocks we may probably assign the rhyolites of Tarawera, Rotorua, and the Thames Peninsula† to the Pliocene period, as well as the hornblende and augite-andesites which form the bases of Ruapehu and Mount Egmont. But very little is known about the sequence of the volcanic rocks of the North Island.

The Great Glacier Epoch.

We now come to one of the most interesting phases in the geological history of New Zealand—I refer to the great glacier epoch. Ancient glacier-marks, principally in the form of terminal moraines, are numerous in the South Island, and they are no doubt of various ages. But it remains uncertain whether they form a single continuous and diminishing series from the earliest records to the present day, or whether there have been two or more periods of marked extension of the glaciers. The most northerly glacier-marks are found round Mount Olympus and the Arthur Range, in Nelson. None have been recorded from the Kaikoura Ranges, although at the present day they are capped with perpetual snow, and none are known in the North Island. The St. Arnaud and Spencer Mountains gave origin to many glaciers. The principal ones on the northern side of these ranges filled the valleys now occupied by Lakes Rotoiti and Rotorua (of the Nelson Provincial District), while to the south and east large glaciers went down the Clarence and the Waiau-ua, the latter being no less than fourteen miles in length. The ancient glacier of the Waimakariri was thought by Sir Julius von Haast to have extended for a length of fifty-four miles, reaching out on the Canterbury Plains as far as Sheffield. This view is open to several objections, but it seems to be certain that the Rakaia Glacier, at the time of its greatest extension, debouched on to the Canterbury Plains, and stretched nearly as far as Woolshed Hill, which would give it a length of about fifty-five miles. Less is known about the ancient glaciers of the Rangitata and Waitaki; but in Otago that of the Clutha certainly came as far as the Lindis, and perhaps to Cromwell, which would give it a length of about

* Trans. N.Z. Inst., vol. xviii., p. 336.

† James Park, Quart. Journ. Geol. Soc. London, vol. 55, p. 451.

sixty miles. The glacier which filled Lake Wakatipu did not drain into the Clutha, but went due south by Athol to the Oreti River. The united glaciers of Lakes Te Anau and Manapouri extended to Blackmount, on the River Waiau, a distance of sixty-five miles, thus being the largest of the New Zealand glaciers. There is also in Otago the remarkable isolated moraine in the Lower Taieri, which forms low hills—some 400 ft. or 500 ft. in height—between Lake Waihola and the sea. This moraine may perhaps be older than any of the others. A few marine fossils have been found in the sandy clays underlying it, which seem to indicate a Miocene age for those beds, so that the moraine itself may belong to the older Pliocene.*

In Nelson the terminal moraines of the largest of the ancient glaciers are about 2,000 ft. above the present sea-level. In South Canterbury they go to 1,000 ft., and in South Otago to 600 ft.; but in Westland and in the West Coast Sounds the glaciers advanced to below the present sea-level. There are, however, no stratified till-deposits, and nowhere do we find the moraines enclosing marine shells, so that there is no evidence that these glaciers descended into the sea. Another remarkable feature is that no boulder-clay has as yet been detected in New Zealand—nothing but the ordinary moraines of valley glaciers. Neither are there any true erratics—that is, large blocks of rock which have been transferred from one drainage system into another. All our erratics have come down the valley in which we now find them.

Now comes the question, What was the cause of this great accumulation of ice in our mountains? We cannot account for it by a colder climate, for there is not the least palæontological or biological evidence to show that our climate has ever been colder than it is now. On the contrary, all the evidence goes to show that it was formerly warmer. Thus in the south we find local outliers of warmth-loving plants and animals which flourish much better in the North Island. Such are the nikau palm (*Areca sapida*) on Banks Peninsula and at Westport, where also *Lomaria frazeri* occurs, a fern which is not found elsewhere south of Auckland. These are survivals of a more genial age in the South Island. Indeed, the greater part of our present flora is of subtropical origin, as also was that of Europe before the cold of the glacial epoch killed it off and largely replaced it by a northern flora. Nothing of that kind has happened in New Zealand. Again, several northern marine shells still live in Foveaux Strait, such as *Triton spengleri*, *Scalaria zelebori*, and *Cookia sulcata*. If New Zealand had lately passed through a cold phase all these plants and

* Report Aust. Assoc. Adv. Science, vol. v., p. 232; Adelaide, 1893.

animals would have been killed off in their southern localities, for there is no place near New Zealand to which, in Pleistocene times, the subtropical flora could have temporarily retreated and then returned after the cold was over.

The same may be said of almost the entire faunas and floras of the islands lying to the south of New Zealand. Yet we find in the Auckland Islands a peculiar genus of duck (*Nesonetta*) which cannot fly, and in Antipodes Island a peculiar parroquet (*Cyanorhamphus unicolor*) which has almost lost its powers of flight. These birds must have been developed on the islands where we now find them, and the process must have been a slow one; yet during the whole of that time the islands could not have been covered with ice. We may extend this argument to other islands in the Antarctic Ocean, such as Kerguelen Land and the Crozets. These possess several peculiar plants and animals, and it is certain that the islands could not have been covered with ice since the first appearance of their present floras. A general reduction of the temperature of the whole Southern Hemisphere being therefore out of the question, we must look for other and local causes for the extension of the glaciers. Two theories have been advanced—one is that our mountains during the great glacier epoch were flat-topped, forming plateaux on which large masses of snow collected; the other is that the mountains stood at a greater altitude than at present, due to a general elevation of the whole Island.

Now, passing over the question whether large snow-covered plateaux necessarily imply large glaciers—they do not do so in Norway—we are met with the fact that most of our river-valleys had been cut down to their present level before the Oligocene period, for rocks of that age fill several of them nearly or quite to the bottom. For example, it is certain that in the Eocene period the Rakaia River ran at a lower level than it does at present. As this is an important point I will give the proofs of my statement.

In the valley of the Rakaia, opposite the east end of Lake Coleridge, there is an outlier of Oligocene limestone called Redcliff. It is lying almost horizontal in its original plane of deposition in a lateral valley on the south side of the river, and is, no doubt, a fragment of a set of beds which once filled all that part of the valley. Now, as this limestone passes under the gravels and descends below the present level of the river, it is evident that when the Rakaia scoured out the valley in the Eocene period it must have been running at a lower level than at present, for it now runs on the top of alluvial gravels which partly fill up the whole valley. Also the junction of the limestone with the Palæozoic rocks must mark the limit of the valley of the Rakaia at that place when

the limestone was formed. If, therefore, any great lateral denudation had taken place since that time, the line of junction between the two rocks ought to stand out as part of a prominence. But it does not do so; consequently, the lower portion of the Rakaia Valley cannot have been greatly enlarged since the Eocene period. This is confirmed by the fact that on the southern slopes of Mount Algidus, in the Upper Rakaia, there is another outlier of Tertiary marine rocks, showing that there also the valley was very deep long before the Pliocene period.

It is therefore very unlikely that a great plateau in the upper part of the Rakaia Valley has been lately removed; and we may say, generally, that as the rivers of the South Island had cut such deep valleys before the Oligocene period it seems impossible, from what we know about river erosion, to believe that any large plateaux could at that time have been in existence—that is, none to which we could attach any great importance.* If also, as we have seen, the New Zealand Alps were formed in the middle of the Jurassic period, and have been exposed to the action of the weather ever since, plateaux of any size could not have existed from the Jurassic to the Pliocene and then have rapidly disappeared, especially at a time when, by the hypothesis, they were protected by a covering of perpetual snow.

This plateau hypothesis failing, we are left with that of elevation to account for the phenomena; and it has been calculated that an elevation of between 3,000 ft. and 4,000 ft. would, at the present day, be sufficient to expand our glaciers to their former dimensions.† That the New Zealand Alps did formerly stand higher than they do now we have direct evidence in the deep fiords of south-west Otago and Marlborough, which must have been excavated when the land was considerably elevated. The greatest depth recorded in the West Coast Sounds is 1,728 ft., in Breaksea Sound; but in many places no bottom was reached with the line used, and we may safely assume that when the valleys were scooped out they stood more than 2,000 ft. higher than they do now. And this agrees fairly well with the quite independent estimate that an elevation of 3,000 ft. or 4,000 ft. would be sufficient to reproduce all the phenomena. In Canterbury also we find evidence of a former elevation, for in sinking a well in Christchurch a quantity of solid timber was found at a depth of more than 400 ft., which must either have grown on the spot or have been brought there by a river. How deep the shingle-beds of the Canterbury Plains go we do not know.

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* See Ann. Mag. Nat. Hist., series 5, vol. 15, p. 91.
† Trans. N.Z. Inst., vol. viii., p. 385.

Lastly comes the question, When did this elevation take place? I will take the biological evidence first. The great similarity between the faunas and floras of the two Islands of New Zealand shows undoubtedly that they were once united; and an elevation of 500 ft. at Cook Strait would connect them again. Nevertheless, we find six different kinds of birds represented by different species in each Island; and this is not due to differences in climate or in the physical features of the two Islands, but to changes in the animals which have taken place since the Islands were separated. It is the same with the extinct moas. Nearly all—perhaps all—of the known species were confined to one or other of the Islands, and certainly none were abundant in both. But this implies that the Islands have been separated by Cook Strait for a long time, during which, of course, there could have been no general elevation.

Still, as I said before, it is evident that the two Islands were once united. Indeed, we may go further and say that in all probability the Chatham Islands, the Auckland Islands, and perhaps Campbell and Macquarie Islands were at one time united to New Zealand by land, for their faunas and floras are closely allied to those of New Zealand, and are quite unlike those of Tasmania.

As no lizards nor land-shells have passed between Tasmania and New Zealand, and as very few birds, insects, and plants are common to both countries, although the distance between them is not much more than twice that between New Zealand and the Chatham Islands, it is evident that our connection with these and with the Auckland Islands must formerly have been much closer than it is now. And the presence of a slug common to all three suggests that there was a land-communication between them.

Now, these outlying islands contain many endemic species of plants and animals, and, in the case of the Chatham Islands, we cannot explain the existence of these distinct species by differences of climate. Out of twenty-one land-birds on the Chathams, seven—that is, one-third of the whole—are endemic. And of the plants about 15 per cent. are endemic. This implies that the Chatham Islands have been isolated for a very long time, and we can say with some confidence that this isolation must have lasted ever since the close of the Pliocene period. But when New Zealand extended so far as to include the Chatham Islands it probably stood at a much higher elevation than at present; and the Pliocene period, therefore, is the time we should expect that the greatest extension of our glaciers took place.

We will now take the geological evidence. In the first place, it is significant that there are no marine Pliocene beds

in the South Island, but only huge deposits of shingle and sand which may well have been derived from glaciers in the mountains. Among the older of these are the Moutere Hills, in the Nelson District, the Mount Grey downs in Canterbury, and the shingle-beds under lava-streams at Timaru.

Secondly, since the culmination of the glacier period several important changes have taken place in the physical geography of the country. The gorges of the Kawarau and Dunstan, as well as those of the Mataura and Upper Taieri, in Otago,* have all been cut, as have also those of the South Ashburton and the Waimakariri, in Canterbury. Also several of the older lakes have been completely filled up, as, for example, those of the Rakaia and the Waiau-ua; while others —such as Lake Heron, Lake Tekapo, and Lake Pukaki—are approaching their end; all of which implies a long time. We thus see that both kinds of evidence place the great glacier epoch in the Pliocene period; and if it should turn out to be true that no older Pliocene marine beds exist in New Zealand, then we may confidently place the greatest extension of our glaciers in the older Pliocene, when both Islands stood higher than they do now. If, however, it should be found that older Pliocene marine beds connect the Miocene with the newer Pliocene in the North Island, then we should have to assume that the South Island alone was elevated in the Pliocene, and that the great glacier epoch may have lasted through the whole of it. However, I think the first supposition to be the more probable.

Pleistocene Period.

During the Pleistocene period the great volcanoes of Tongariro, Ruapehu, and Mount Egmont emitted andesite lavas, while basalts were erupted in the neighbourhood of Auckland and near the Bay of Islands.

The old swamps, or lakes, in which such a large quantity of moa-bones have been found, also belong to this period, and as they have attracted much attention a word or two in explanation may be interesting. At the time when these large deposits of bones were being formed the climate of New Zealand seems to have been different from what it is now. This was probably due to a greater eccentricity of the earth's orbit; for then, when our winter happened in aphelion, long cold winters would be followed by short but hot summers. The heavy snows which fell during the winter would be rapidly thawed in the spring, with the result of producing heavy floods. This was our diluvial epoch, which followed the great glacier epoch.

* "Report on the Geology of Otago," Dunedin, 1875, p. 94.

Now, it seems likely that during this time the early winter snows would kill many moas, as well as other birds, on the hills, and that their bodies would be washed down on to the lower grounds by the spring floods, so that in time immense quantities might accumulate in the hollows. This speculation is much strengthened by the fact that no large deposit of moa-bones has ever been found in any of the swamps on the plains away from the hills, either in Southland or in Canterbury, or in the Waikato and Piako districts. However, we should also remember that some parts of these plains may have been below the sea at that time, for we have evidence that after the culmination of the glacier epoch a great depression of the land took place until it stood lower than it does now.

Raised beaches with recent species of marine shells have been found at Tauranga at an elevation of 25 ft. above the sea; at Taranaki, 150 ft.; at Amuri Bluff. 500 ft.; and at Motunau, 150 ft. above sea-level. Also old marine terraces, but without shells, exist on Mahia Peninsula at 200 ft. to 300 ft. of elevation, as well as near Wellington; and all along the west coast of the South Island as far as Green Islet, south of Preservation Inlet. We may therefore safely infer that the South Island and the southern part of the North Island sank in the Pleistocene to a considerably lower level than they now attain, and that they are once more rising.

The evidence given by the alluvial deposits of our rivers is also quite in accord with that of the sea-terraces. When the land was sinking the rivers filled up their valleys and formed the broad alluvial plains so common from Southland to the Waikato. When the land began to rise again the remarkable series of river-terraces which catch the eye in most of our valleys were formed out of these alluvial deposits.

The origin of the silt deposit—sometimes called loëss—which is found on the eastern side of the South Island is a difficult problem to solve. It is found chiefly from Invercargill to the Mataura River, and from Oamaru to Timaru and Banks Peninsula, lying on the low hills and on the river gravels. It evidently forms the latest deposit in every locality in which it is found, and it is equally evident that it is not being formed now. Two theories have been advanced to account for it. One is that it is a wind-formed deposit analogous to the sand-dunes of a desert. The other is that it is a marine deposit, but formed very rapidly by the floods of our diluvial epoch washing away the fine mud left by the retreat of the glaciers.* Many objections can be made to both of these theories, but it would detain me too long to discuss them.

* Trans. N.Z. Inst., vol. xv., p. 411.

Changes in Physical Geography.

New Zealand also offers for solution many problems in physical geography, due to the changes which have taken place since the Cretaceous period, which are very interesting to those who know the ground. But time warns me that I can only glance at a few of them.

Lake Wakatipu and the Arrow River formerly drained into the Oreti River by Kingston and the Dome Pass. Subsequently, the Kawarau and Dunstan Gorges were cut, which allowed the lake to flow into the Clutha. This change seems to have been due to the moraine at Kingston blocking the former channel, and causing a lateral overflow at the Arrow Bluff. To the same cause—*i.e.*, to morainic deposits—we must attribute the change in the drainage of Lake Heron from the Rangitata into the Rakaia River. The Shag River at one time drained the Maniototo Plains, until the gorge of the Upper Taieri was cut. In early Cretaceous times the Hurunui and the Waiau-ua united, and entered the sea at Kaikoura. At a later time they turned down the Weka Pass, and it was not until the Pliocene period that each cut its own valley to the sea. The Upper Manawatu flowed into the Wairarapa, and in the older Pliocene a river ran from near the Manawatu Gorge to Napier. The courses of all these rivers were changed by the deposition of marine rocks in the valleys, which blocked them; and this, on the subsequent rise of the land, caused the rivers to overflow to one or the other side, according to the position of the lowest opening.

The River Waikato at first flowed through the Waiotapu Valley into the Bay of Plenty. Its direction was disturbed by volcanic action in the Rotorua district, and its course was then deflected into the Hauraki Gulf. There it remained until the gorge at Taupiri was cut. What caused this last movement has not yet been clearly made out; but probably it was due to changes in level during the last upheaval of the land when the dome was formed on which Tongariro and Ruapehu now stand.*

Summary.

I will conclude with a short summary of the results at which we have arrived.

Of what took place on this part of the earth's surface during the early Palæozoic era we know next to nothing; but towards the close of the Devonian period land certainly existed, although its outlines are quite uncertain. This land must have sunk, for in the Carboniferous period a deep sea rolled where New Zealand now is, while far away to the

* Cussen, Trans. N.Z. Inst., vol. xxvi., p. 398.

north-west there was the Continent of Australia, with vast mountain-ranges covered with snow, and with glaciers glittering in every valley.

This state of things lasted into the Permian period, by which time the bed of the ocean had been gradually raised, so that the sea became shallow, and the New Zealand area lay near the shore-line of a continent stretching away towards Tasmania and Australia, to which, perhaps, it was joined. This land was covered with ferns and Cycads, and probably there were a number of active volcanoes ejecting rhyolitic lavas. But what animals lived on the land we do not, as yet, know.

In the middle of the Jurassic period came a violent upheaval. The rocks were crumpled up, the coast-line was changed into a mountain-range, and the land between it and Australia sank, forming the Tasman Sea The new land, which we may now call New Zealand, for it has never since been entirely covered by the sea, extended in a westerly direction to at least twice its present breadth, and to the north it joined New Caledonia and New Guinea, which at that time probably formed part of a South Pacific continent. Plants and animals—including snails, worms, and insects, but no birds—came trooping down from the north to form the basis of our flora and fauna.

A long period followed, in which the western side of the mountains of the South Island were constantly being worn away by the heavy rains brought by cyclones sweeping over the Tasman Sea ; but this did not take place to so great an extent in the north, for in those latitudes westerly winds are not so prevalent.

In the Upper Cretaceous the land subsided, and New Zealand was reduced to comparatively small limits. This land, however, supported many angiospermous trees, as well as gymnosperms, whose descendants are still living ; while in our seas were marine reptiles and shells which have long since become extinct.

A little before the commencement of the Tertiary era the rocks were folded once more, the land rose again, and again it stretched far away to the north, but was not again united to New Guinea nor to northern Australia. A second invasion from the north followed, and quantities of plants of all descriptions, accompanied by animals — among which were many land-birds—migrated into New Zealand, and it is the descendants of this Eocene invasion which form the greater part of our present flora and fauna.

This was the last folding of rocks in New Zealand on an extensive scale, for all the younger rocks usually lie in the same position in which they were originally deposited, and

circle round the bases of hills formed by older rocks. Not only was the last touch given in the Eocene period to the internal structure of the mountains, but the chief valleys were also deeply scoured out, so that when the land sank again in the Oligocene period these valleys were filled up with marine limestones and other rocks.

The Oligocene and Miocene were periods of depression, separated by a slight upheaval which lasted only for a short time. During most of the Middle Tertiary era New Zealand must have formed a narrow ridge of land, very irregular in shape, running north-east and south-west. with some detached islands on each side, three or four on the south-east side, and a dozen or more to the north-west, none of them being very high above the sea.

In the older Pliocene came the last great upheaval. All the islands were joined together, and the land stretched away to the east and south so as to include the Chatham and Auckland Islands, as well, perhaps, as Campbell and Macquarie Islands; while to the north it certainly extended to the Kermadecs, and perhaps much further. On the mountains of the South Island large glaciers were formed, and the torrential rivers running from them tore into disconnected fragments the Miocene marine rocks which obstructed their valleys. Probably at this time more land than at present existed in the Antarctic Ocean, for New Zealand added to its flora and fauna many antarctic plants and marine animals. But this land could not have connected New Zealand with either Patagonia or South Africa, for if it had done so we should certainly have had many more immigrants, including land birds, and, probably, mammals.

It is possible that this large extension of land to the eastward may have produced desert or steppe-like conditions in a portion of New Zealand, evidence of which some botanists think they find in our flora; also, in the old lake at Kapua, near Waimate, there is some slight evidence of a dry epoch having, at that place, succeeded the diluvial epoch during which the moas were buried.* But this may have been due to quite local causes.

Subsidence seems to have commenced first in the southern portion of the North Island, for in the newer Pliocene large portions of what are now dry land were under the sea, and Cook Strait had been formed. But at a later date sinking began in the South Island also, so that in the Pleistocene period the sea at Amuri Bluff stood at least 500 ft. higher than it does now. This sinking has again been followed by an elevation of all parts of New Zealand, the centre of the

* Trans. N.Z. Inst., vol. xxviii., p. 629.

North Island rising as a low flat dome, on the summit of which stand Ruapehu and Tongariro; while the South Island has also been elevated several hundred feet. And this elevation appears to be still going on.

This short sketch will, I hope, show you that New Zealand has had an eventful history, and we need not be surprised if we still occasionally feel it to be somewhat unsteady.

TABLE OF THE GEOLOGICAL FORMATIONS OF NEW ZEALAND.

Name of Formation.	Probable Age.
Cainozoic System—	
Wanganui series	Newer Pliocene.
Glacier epoch	Older Pliocene.
Pareora series	Miocene.
Oamaru series	Oligocene.
Waipara System	Upper Cretaceous.
Hokanui System—	
Mataura series	Lower Jurassic.
Wairoa series	Triassic.
Maitai System	Permo-carboniferous.
Takaka System—	
Baton River series	Siluro-devonian.
Aorere series	Ordovician.
Wanaka System	Pre-cambrian.

ART. XXII.—*On the Geology of the District between Napier and Puketitiri.*

By H. HILL, F.G.S.

[*Read before the Hawke's Bay Philosophical Institute, 14th August, 1899.*]

A TRIP to the Kawekas by way of Puketitiri is a pleasure not easily forgotten by any one fond of nature. These mountains lie to the north-west of Napier, at a distance, speaking generally, of fifty miles. The range is isolated, being separated from the Ruahine Ranges in the south by a long low saddle, through which the River Ngauroro passes, and from the Te Waihiti and Raukumara Ranges to the north and north-east by a wide area of broken country, through which traverse the head-waters of the Mohaka River.

The Kaweka Mountains and offshoots may be said to form the watershed of the Rivers Ngauroro, Tutaekuri, and Mohaka, the two first rising within a very short distance of each other. Between Napier and the mountains the general strike of the rocks is north-east and south-west, so that in traversing the country from north-west to south-east the strike of the beds is crossed, and

good sections can be studied by the way, more especially along the watercourses, which generally proceed in the direction of the dip of the beds. The country from the mountains to Puketitiri may be included as forming a part of the range, although the rocks on the range of hills fronting Puketitiri are, speaking geologically, different. The mountains themselves in some places show rocks with a slaty cleavage. These are mixed with a pale-red sandstone of a fairly fine texture, and corresponding to the rocks at the top of the Ruahine Range at the back of the Whakararas. They are highly denuded, and since the destruction of the scrub and native grass the high winds have bared them, and now thousands of acres consist of bare rock, which sun and frost and rain break up at a rapid rate—so rapid, in fact, that no growth is at present possible.

On the top of the highest part of the mountains I was much interested at observing a series of parallel lines of loose rocks arranged irregularly in line as is done by little children when playing with stones. I could only account for their presence by supposing ice-movement from a higher elevation, when the stones are brought down and deposited in irregular lines as morainic *débris*. Snow does not rest for more than three months in the year upon the mountains, but the falls appear to be heavy at times, and possibly a slight movement of the snow takes place as soon as the sun is sufficiently powerful to act upon it, at a time when the atmospheric changes are most rapid. The ridge that separates the sources of the rivers is quite narrow, and one can imagine the time when the country further westward was open to the east, and when only a single large river flowed from the lands in the direction of Ruapehu and Taupo, bringing down great volumes of pumice, shingle, and timber, the latter being the result of the destructive outbursts from the volcanoes in the district.

The range of hills immediately joining the mountains on the east side is known as the Birch Range. The Makahu Stream flows between the two, and runs to the north-east to join the Mohaka, that comes further from the westward. These hills may be set down as forming a part of the main range, as they are geologically the same. Denudation, however, has played havoc with them, and they seem as if they had been shattered and shaken and broken at the time when the mountains were in process of elevation. This range is again separated from another line of hills which forms the northern end of a series of rocks—limestones, sandstones, and other—which are met with along the foot of the entire Ruahine Ranges. In some places the rocks are fairly compact limestone; sometimes they are hungry-looking sands, such as are seen topping the slates in different places.

At the top of the hills on the Napier–Kuripapango Road, known as "Blowhard," the sandstones run into a peculiar fluted limestone, as described by me in a former paper. Further northward the limestone disappears, except here and there, and a brownish-grey hungry sandstone, mixed in places with a grit conglomerate, takes its place. This sandstone country has been subject to great denudation, and the whole of the Puketitiri district presents remnants of this sandstone and nodular limestone, into which the former passes as it dips to the south-east.

In order, however, to comprehend the full sequence of rocks in the district under notice it is necessary to imagine what the country was at the time when the drainage was to the south-west. The slope was towards Hawke's Bay, but a deep valley lay between the rising mountains and the range of limestones, whose scarp showed a fracture running north-east and south-west, and facing the north-west. This deep valley can be traced for many miles, for the scarp is as definite to-day as when the upward pressure fractured the limestones which at that time covered the entire area in the direction of Ruapehu. I took a photograph of one section of the scarp, on the ridge between Puketitiri and Hawkeston, the residence of Mr. J. Hallett, which shows a face as if cut with a knife. The elevation of the Kawekas and the fracturing of the rocks to the eastward caused a break sufficiently large for the entrance of the sea so as to form deep bays and inlets, and in various parts of the district fossiliferous sands and impure limestones are met with topping limestones which belong to the Upper Miocene beds. I do not think these younger beds of fossiliferous sands and limestones are to be met with to the north of the 39th parallel of latitude, which may be said to be the northern boundary of Hawke's Bay; but it is also a curious fact that shingle conglomerates and attendant sands do not appear to the northward of this parallel, whilst they are very highly developed to the southward. The limestones which present in their scarps such a characteristic feature in the landscape belong to the Upper Miocene beds. They abound in fossils, and in some places the large oyster *Ostrea ingens*, which is characteristic of what are known as the Te Aute limestones, forms immense banks, presenting the appearance of artificial banks of oyster-shells. On the hills a mile or so to the north of Mr. Hallett's homestead there are scores of acres of these shells, and they are arranged so regularly atop of each other that it is difficult to imagine how they lived.* Certainly they represent a long period of de-

* How they managed to obtain food crowded so thickly together as they were one above the other is a mystery, but the fact remains that the oysters, of immense size, shell upon shell, existed by the million.

position; and yet there is no trace of a break, an intrusion, or a change in the direction of currents. In some places hardly another variety of shell—except a *Patella* or a *Balanus*—is to be found, and yet within a score or two yards are other banks containing a whole museum of specimens. I have taken photographs of several of the banks, and have made lantern-slides to show what life there must have been thereabouts in the days when the oysters were at their prime. Such deposits in these days would satisfy even the demands of a city like London for years, although I doubt whether epicures of this bivalve would have wished for an oyster-supper where *one* or *two* oysters at the most was sufficient for a meal!

The Miocene beds continue from Puketitiri in the direction of Patoka, changing somewhat their rock characters as they proceed. The limestones are seen to rest upon a pale-blue sandy limestone and marl, containing plenty of fossils, such as *Struthiolaria*, *Cytherea*, *Pecten*, *Natica*, *Murex*, and *Ostrea*. At the Patoka Hill laminated limestone is inter-bedded with fossiliferous sands, and these are seen to be above the marly limestone containing the fossils just named. Few or no fossils are to be seen in this laminated limestone, although traces of broken shell, such as *Pecten* and *Balanus*, can be distinguished.

Proceeding towards Napier from Patoka the country appears rugged and broken. We are now on the eastern slope of the Titio-kura limestone range, of which Te Waka is such a prominent point from the Napier bluff. Immediately following the Patoka Hill is a smaller one at its foot, and this is quite different in structure from the rocks that have been hitherto met with. We are now in the line of the conglomerates, which, commencing north of Pohui in sands and grit, strike to the south-west and intrude themselves everywhere, sometimes resting beside the limestones, sometimes replacing them, and sometimes being apparently mixed with shelly limestone, and so thrusting themselves everywhere till they partly lose themselves in the Ruataniwha Plain.

Whenever I come among these conglomerates there always arises in my mind a doubt as to their age, and yet they can be traced regularly over a large area of this district. Sometimes I have been inclined to the opinion that they are contemporary with the Pliocene limestones which appear overtopping the Miocene deposits as far back towards the mountains as the Birch Hills; at other times they seem to me as belonging to the Miocene beds; and yet there can hardly be a doubt that they were deposited subsequently to the Pliocene beds, and during their deposition the Miocene and Pliocene deposits were greatly denuded. In fact, with

the exception of the higher lands, all the Miocene and Pliocene limestones were subjected to severe erosion, and were replaced by enormous accumulations of sand, shingle, conglomerate, and lignite lands such as now cover such a large extent of country.

Between Patoka and Rissington the whole area is covered with a conglomerate deposit which varies in structure, sometimes presenting walls almost like a face of limestone, sometimes being of a deep-brown grit, and at others passing into sands and shelly conglomerate. The shells where seen are mainly the cockle and the oyster. It would appear that the shingle-conglomerates were deposited within the vicinity of salt-water, for bones are not uncommon, as the workmen who quarry the conglomerates for roading often find large bones, which appear to belong to a cetacean of some kind. I have several of the bones so found, and specimens were sent to Sir James Hector by a Napier gentleman, who received intimation that they belonged to a cetacean.

At Rissington the blue-clay marls, which form the lowest beds of the Pliocene deposits, are well exposed, and on the top of them are seen resting shingle and conglomerate which have evidently planed down the clays and carried away the limestones.

As you rise the hills in the direction of Mr. Bennett's homestead at Wharerangi the limestones again make their appearance, and with them here and there are traces of the shingle-conglomerates, which evidently at one time swept across the tops of what are now the highest hills hereabouts. Traces of the shingle may be noticed descending the hills into the valley which opens at Puketapu into the Tutaekuri River, but their appearance is such as to bring doubts into the mind regarding their true stratigraphical position. From the valley the road passes over the hills in the direction of Napier, and here the well-known upper limestones of the Napier series are met with, whilst in certain places of the inner harbour the shingle-conglomerates make their appearance on the top of the blue marls, which represent the middle beds of the Napier series.

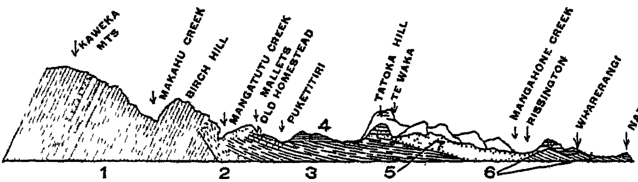
It may be that the shingle deposits that are met with here and there from the top of the hills beyond Wharerangi to Napier were deposited from a different stream from that which swept over the whole country between Patoka and Rissington, or perhaps the stream with its burden of shingle was diverted somewhat further to the southward. In any case, the limestones were left in the district between Wharerangi and Napier, whilst they were replaced further to the south-west, where remnants remain mixed with shingle, as if solidification had taken place after the shingle had passed over the dis-

trict. The deposits which were carried down the valley at Puketapu make their appearance at Redcliffe, and are seen again in the direction of the Kidnappers, where they form cliffs several hundreds of feet in height.

It is needless to speak as to the general characters of these beds; they have already been described by me. It is clear that important surface changes have taken place since the deposition of the conglomerates. Elevation and depression have alike been active; lateral and transverse valleys have been worn down in a hundred places, but the remnants that remain enable the past to be read in unmistakable language.

Height of mountains, 5,000 ft.; Puketitiri 1,800 ft.

The following is a cross-section from the Kawekas to Napier:—



(1.) Trias.
(2.) Miocene.
(3.) Pliocene.
(4.) Pleistocene.
(5) Post-pliocene.
(6.) Recent.

Art. XXIII.—*On the Volcanoes of the Pacific.*

By Coleman Phillips.

[*Read before the Wellington Philosophical Society, 12th December, 1899.*]

Third Line or Area of Elevation.

Having completed my second line of activity,* I will now follow the third line or area of elevation west to east along the 20th parallel of south latitude, which includes the greatest breadth, as it were, of the Pacific volcanic groups, from the coral sea bordering Australia to Easter Island; although here again it might be more correct for me to include the volcanic islands in the Malay Archipelago itself, and make the area one of elevation from Sumatra to a little to the eastward of Easter

* See Trans. N.Z. Inst., vol xxxi., Art. xlix.

Island in a general north-west and south-east direction, including as far north as the Philippines, and so as to embrace the greatest number of the Pacific islands. The actual trend of the islands will be found lying generally in a west-north-west and east-south-east direction, although many vary from those points.

Professor Milne places this area in his map as one of subsidence, wherein it will be seen how greatly we differ. The trinolith at Tongatabu happens to be a very good landmark as to sea-levels, and it shows that that island, at any rate, has not subsided 6 in. a century for the past three or four thousand years. Instances are within our own knowledge of the rapid growth of volcanic islands. "In 1796 a volume of smoke was seen to rise from the Pacific Ocean about thirty miles to the north of Unalaska. The ejected materials having raised the crater above the level of the water, the usual volcanic phenomena occurred. Repeated eruptions have increased the dimensions of the island until now it is several thousand feet in height and between two and three miles in circumference." So that there is really no geological objection to the upheaval and formation of any of the groups of islands in the Pacific.

I am at once met with the objection that there is no line of present volcanic activity along the 20th parallel of south latitude. That is so; but nevertheless a glance at the map shows that there has been a line of upheaval, and my duty is to record in such a paper as this all the evidence I can collect bearing upon volcanic action in the Pacific, a region which hitherto has not met from vulcanologists that attention which it merits—the grandest volcanic region, I take it, upon the face of the globe. Great earth-oscillations doubtless occur in this immense water-area—seventy million square miles. There could not, of course, be so much volcanic activity without this vast water-area. The pressure of 30,920 ft. of sea-water near Tonga upon each foot of the ocean-bed at 62½ lb. to the foot can be readily calculated. Such a column of water would readily find out any weak crack or crevice to reach the central heat or the imprisoned lava within the earth's crust. But, of course, the more surface-water that pours in the more quickly steam is generated, which by upheaval closes up the fault or crevice.

Thus, as I have already said, the bottom of the ocean is blistered by upheavals and volcanic growths—viz., the various groups of islands—and although we find no active volcanoes along this third line, yet I am not prepared to admit that volcanic action is quiescent, for one of the greatest tidal waves on record within the past twenty-five years arose from a submarine explosion in 21° 22′ S. latitude and 71° 5′ W. longitude—the 1877 wave described by Milne and others, which,

like the wave of 1868 and all the other great waves, travelled almost the length and breadth of the Pacific.

Accepting as a maxim the statement that an earthquake is an incomplete volcano, the islands along this line experience pretty sharp earth-movements; at present correct observations of them are not taken at all. Thus as I write news comes (dated 8th August, 1899) of a tidal wave which burst into Valparaiso Bay, damaging Government property to the extent of millions of dollars. Great parts of the embankment were carried away, and railway-cars and locomotives were dashed off the rails and embedded in the *débris*, the rails being torn and cranes smashed. Many thousand tons of merchandise were destroyed. The State railway between Bellavista and Baron was completely wrecked. This may only have been a local phenomenon, but a few of the islands in the Paumotus are sometimes washed clean by tidal waves.

The continuous pressure upon the ocean-bed at the deepest soundings between Tonga and New Zealand at 800 tons to the foot (34,848,000 tons to the acre, and 22,400,000,000 tons to the square mile) is so enormous that it is no wonder we find great volcanic activity within a certain radius from it. Where are we to look for the balance? At our hot-lake district in New Zealand, or at Tanna or Ambrym, in the New Hebrides? Supposing we found thermal action going on regularly at eight- to ten-minute intervals in the geysers or fumaroles at our hot lakes, or similar discharges at Tanna or Ambrym in the New Hebrides, might we not conclude that these are the safety-valve escapes from the enormous pressure referred to, and that the regularity of the escaping steam proves a certain connection within the whole circle of which the points referred to are radii? The pulsations fairly average twelve minutes at the three points named, yet some sixteen hundred miles apart; so I think Sir James Hector ought to grant a greater area of unity in volcanic phenomena than he does.

It will be seen, too, that I differ very considerably from Milne's chart in my three lines or areas of activity and upheaval, as he gives them all as subsiding. It may be he is right with regard to those islands near to and north of the equator and with Easter Island and with some of the Paumotus; but the really subsiding area in the Pacific—viz., an ocean band of about a thousand miles in width following the south-east and north-west trend of the western coast of the American Continent—he does not give at all. But even this subsidence is so slight as to be almost unnoticeable, for we can even not be guided by the Easter Island images, whose gradual subsidence may be only a local phenomenon, as I fancy much of the subsidence amounts to in the Pacific.

The one real and prominent fact in regard to the island groups in the Pacific is that they have been upheaved, since which a certain amount of subsidence has followed, but so slight that, as I have said, the Langiis at Tonga still remain much as they were built some three or four thousand years ago. There may be now a period of rest, but even that supposition I cannot agree with, so many slight changes do I know of taking place. I must say that Milne concludes his book in quite as uncertain a frame of mind as I am myself. The field is so vast and our knowledge so slight. The coral borings at Funafuti may tell us something, but even the sinking of a volcanic hill or blister near the equator some 1,500 ft. below the sea after upheaval, somewhat like Falcon Island, but to a greater depth, may only be a local phenomenon, telling us nothing of the general law of lines of activity or subsidence to which I am referring in this paper.

The opinion of leading geologists belonging to this Institute is that there are no "lines of activity," each volcanic rent being local to itself. What, then, of the great line running north to south, bordering the Pacific, in the two American continents? And another line might be drawn fringing the Pacific on the other side—namely, through Japan and the Kurile Islands.

Beginning with the phenomena upon the islands where the first two lines of activity intersect each other—viz., the Loyalty Islands: Attention has already been called to the Rev. Mr. Turner's remarks "that Lifu is an uplifted coral formation, the highest land on the islands being about 300 ft. above sea-level; and Mare a mass of uplifted coral, also bearing marks of two distinct upheavals."

The peculiar formation of the islands lying off the mouth of Nei-afo Harbour in Vavau (Tonga) now require reference. The whole of them appear to be at an exact uniform level of 100 ft. to 200 ft. above the sea, evidently showing the same upheaval. They look just as if they were bits of reef upheaved. In no other way could they have acquired their flat tops and straight sides. "The power which exhausts itself in the eruption of a volcano often shows itself by the changes it produces in the level of the surrounding country." I do not think that any land in the three great islands of Tonga is much more than 300 ft. above sea-level; Tongatabu much lower. The highest land I know is in Vavau: that island contains a great open grassy plain about 200 ft. high, unstocked, owing to the absence of water. The soil of Vavau and the surrounding islands is an excellent rich brown one, evidently volcanic. No doubt this soil came from the original volcanic rock, which has weathered, decomposed, and speedily clothed itself with vegetation.

It will be seen at a glance what an excellent soil the brown gravel in the little specimen-bottle upon the table from Falcon Island (now sunk below sea-level) would decompose into if allowed sufficient time; so that from this specimen it can be seen how much of the volcanic soil in the Pacific has been formed. I obtained the gravel before the island disappeared.

There is no water, as I have said, in Tonga except that which is caught in tanks, nor is rain very abundant there, but the night-dews are heavy. The natives bathe in the sea, and use very little water for cooking purposes; their chief drink being from the cocoanut. Their cooking is done by pouring about a pint of water into a huge earthen pot, closing the neck, and converting the water into steam. Clothes they do without, so that the thirty thousand people there rub along very well without much water. The Europeans, of course, use tanks, but the water these tanks contain must be a living mass of microbic germs.

Pylstaart, Kao, Letté, and Tofua are separate small islands to Tongatabu, Hapaai, and Vavau, and tower up, as I have said, from 700 ft. to 3,000 ft. They may have attained these heights by sudden growth, and yet not altered the levels of the three large islands.

Writing of Savage Island, Mr. Turner says, "It is an uplifted coral island 300 ft. above the level of the sea, about forty miles in circumference, in 19° S. latitude and 170° W. longitude." It will be noticed that Savage Island, the Tongan Group, and the Loyalties, stretching some twelve hundred miles west to east, show an upheaval of 50 ft. to 300 ft. above sea-level.

The Cook or Hervey Group, over five hundred miles to the eastward, may also be embraced in this line, for with the exception of Rarotonga, which is volcanic and mountainous, the other islands consist of ancient coral formation raised 20 ft. to 200 ft. above the sea, some of them lower, and all surrounded by living coral reefs.

Mangaia, the southernmost island of the group, is of coral formation, but otherwise differs from most of the South Sea islands outside this group. It is about 650 ft. high, and at a distance appears quite flat. There is a fringing reef all round, about 2 cable lengths from the shore, and about 2 ft. above high-water mark, but with no passage for boats. Boats anchor outside the reef on a ledge, and canoes come off for passengers, &c. The natives then look out for the rise of the swell, land the canoes on the reef, jump out quickly, and drag the canoe to land before the receding sea can sweep it back into deep water. These facts go to prove a late upheaval at Mangaia.

Yet Rarotonga, a hundred miles west by north of Ma-

ngaia, is 2,920 ft. in height, seven miles long, and four miles wide, with the usual barrier reef. Of course, there is nothing to have prevented Rarotonga having been upheaved 200 ft. to 600 ft. at the same time as Mangaia was uplifted. So with Atiu or Vatiu Island in this group (latitude 19° 59′ S., longitude 158° 6′ W.), whose formation much resembles Mangaia, with a reef closely fringing the shore. Its highest point is 394 ft. above sea-level.

I cannot say whether the sides of these two islands are perpendicular or show two or more upheavals. My friend Mr. Moss, the late British Resident there, may be able to tell us, but I should think they would show either one or two upheavals, as nature generally acts slowly in such changes. The islands at the entrance to Vavau Harbour and the heads of that harbour itself are straight up and down—so much so that the men-of-war use them for target-practice. I should therefore suppose that this area of upheaval, when it occurred, rose about 200 ft. On the other hand, it may only have been tilted up by slow degrees, like the western foot-coast of the South American Andes, in the supposed crumpling or buckling of the earth's crust. But the islands present so upheaved an appearance that one is led to that conclusion. A careful study of the rock-formation of each islet will settle the question. If the rock is old coral-formation upheaval cannot be questioned.

The 200 ft. to 300 ft. upheaval is also shown in the Austral Islands, lying further to the east and southward. These islands are high and fertile, Rurutu having a high central peak with lower eminences sloping to the shore. Around the foot of the mountains is a plain about a quarter of a mile wide, which consists of coral-formation, well covered with earth washed from the sides of the adjacent eminences, which has gradually constituted a soil teeming with luxuriant vegetation. Large coral masses rise here and there, abruptly in some instances, to the height of more than 200 ft. above the beach.

The Society Islands, rising 7,000 ft. above sea-level, show great ancient volcanic disturbance, but space will not allow me fully to describe them now. In Tahiti, the most important island of the group, volcanic substances, stratified, broken, and thrown up in the wildest disorder, are everywhere to be met with.

In the Paumotu, or Low, Archipelago there are many evidences of upheaval, and, of course, subsidence. The soil of Pitcairn Island, where the mutineers of the "Bounty" took refuge, is very rich but porous, a great portion being decomposed lava, the remainder a rich black earth. I should consider Henderson or Elizabeth Island (latitude 21° 21′ S., longitude 128° 19′ W.) within the range of the line of up-

heaval I am now referring to. According to Captain Beechey the island is five miles long and one mile wide, and has a flat surface, nearly 80 ft. above the sea. All sides, excepting the north, is bounded by perpendicular cliffs, about 50 ft. high, composed entirely of dead coral, which are considerably undermined by the action of the waves. (This is exactly what one sees at Vavau, Tonga, and I recommend visitors not to miss pulling into one of these caves at the entrance to Vavau Harbour). Byron's Cave there, I expect, was similarly formed.

The external form of the Gambier Islands, in the Paumotus, conveys at once an impression of their volcanic origin, but the seventy-eight islands or groups of islands comprising the Paumotus are generally low islands almost a-wash. The hurricane of 1878, indeed, swept over some of them, carrying every living thing away. It is not often this group is visited by such cyclones. Many of the inhabitants saved themselves by tying themselves to the trunks of trees. It may be that the whole of the Paumotu Islands, under the 200 ft. level, appeared above the sea at the same upward movement to which I am at present referring. The uprising tapered off, as it were, at a little beyond Easter Island, and affected the whole equatorial area right through, perhaps to the western coast-line of the Australian Continent. It will be noticed that the 20th parallel of south latitude very nearly cuts all these islands.

The distance from the Loyalties to Henderson Island is about 3,580 miles, and the evidence which I have been able to produce shows one area of upheaval. It will be noticed, too, that this line is almost at right angles to the first line of present volcanic activity referred to in this paper, bounding the 180th parallel of longitude from Tarawera to Nei-afo, a distance of fifteen hundred miles, or in its fullest extent from Mounts Erebus and Terror to the equator, a distance of about four thousand five hundred miles; the second line of activity, from Hunter Island and through the New Hebrides, the Solomons, and New Britain, &c., to the longitude of Vulcan Island in New Guinea or Uap in the Carolines, being fully 2,250 miles; but this latter line would be better extended another two thousand miles of eastern longitude, so as to include the whole line of present activity through the Malay Archipelago.

Reference will be made directly to the islands immediately bordering on and north of the equator, which are all, with few exceptions, low and small. All these show subsidence. There are a great number of crescent- and low-shaped atolls in these northern, central, and eastern portions of the Pacific; also small, circular, sunken patches of coral, showing that during the

subsidence which accompanied and succeeded the upheavals the coral-polyp started its labours on the top of an extinct volcano or from a rugged ridge or peak. The evidences are common in the Pacific for a volcanic hill to subside, the crater to become a lake or a lagoon, the island to sink still further, and end in being an atoll or a crescent- or low-shaped reef, or finally a sunken coral-patch. At the same time, with these evidences of subsidence, there is this third area of upheaval. Nor can there be subsidence in the earth's crust without upheaval somewhere. But my task is only to record the facts I have seen or collected regarding these islands.

We must ask residents in the islands to keep a careful record of observation in land- and sea-levels. At present it may only be that the Pacific Ocean is deepening slightly in consequence of a slight shallowing of the Atlantic or Indian Oceans, which would account for the marvellous energy of the coral-polyp—an animal that must go on building as the waters deepen. Neither in the Atlantic nor Indian Oceans is there anything approaching the coral-growth we find in the Pacific. At Easter Island the carved tuff images are slowly descending into the sea. In the physical geography of the earth I am inclined to the belief that all change is slow and gradual, and not violent. At times, here and there, we experience a great volcanic eruption, but it is confined strictly to a very circumscribed locality.

Soundings amongst the islands are very steep—200 to 600 fathoms (1,200 ft. to 3,600 ft.), and this sometimes close up to the reefs. One can easily understand this, however, looking at the rugged volcanic shape of the islands of Fiji, Samoa, or Tahiti. And the deepest soundings on earth, as already pointed out, lie between New Zealand and Tonga—5,155 fathoms (30,930 ft.), latitude 30° 27′ S. and longitude 176° 39′ W.; so that the oceans would have to overflow the tops of the Himalayas a couple of thousand feet before the supposed sunken Pacific continent could be again exposed.

Let us suppose a piece of land a hundred miles square, like the narrow neck between Auckland and Onehunga, containing a similar number of extinct craters sunk beneath the sea in the tropics. The coral-polyp would begin its labours directly from the top of the different extinct craters, go on building upwards to the sea-surface, and we should have all the evidences of atolls and circular-shaped reefs, but not, of course, on so large a scale as we find in the Pacific.

In the Sandwich Islands the United States steamer "Tuscarora," at a distance of only forty-three miles from Molokai, found 3,023 fathoms, or over 18,138 ft. Add this to the height of Maunakea, the highest point in Hawaii (13,805 ft.), and we have 31,943 ft., or 3,773 ft. higher than the loftiest peak of

the Himalayas, which is only 28,170 ft. Am I therefore justified in slightly doubting this "sunken continent" theory, and in thinking that our equatorial belt and polar depressions must have been fairly fixed in their present positions at the original cooling of the planet, and, from the volcanic phenomena in the Pacific, that our views of geological science must be modified.

I would point out the great lengths and breadths of the volcanic lines I have been speaking of. The islands forming the Wallis Group show the 200 ft. upward or outward thrust equally with the Tongan islands. These small islands do not show any lines of fracture on the land, but rather a distinct outward thrust. It appears as if the earth's crust uprose in this special geographical area in prehistoric times some 200 ft. to 250 ft. in one gentle movement, since which time the islands have remained about stationary, the ocean waves, however, washing them slowly away. Their flat tops or sharp peaks to me show every evidence of their former submergence. Nevertheless, each insular spot may only be a local upheaval, like the Sandwich Island volcanoes. But I am endeavouring to prove that there has been upheaval, and not all subsidence, in the Southern Pacific (the present accepted belief). It looks as if there has been a tilting, the islands along the 20th parallel of south latitude rising, and those at the equator and to the north of it sinking. Then, a crumpling is evidently taking place between Tahiti and South America, the Andes rising slightly and the ocean-bed sinking slightly, the Paumotus being proof of the upheaval being all old coral. Of course, I do not doubt a local slickenside action at any one spot, such as occurred at the Hanmer Plains, in New Zealand, or at Tacoma quite lately, on the North Pacific coast of America, when 600 ft. of docks belonging to the Northern Pacific Railway Company disappeared into the bay. The local subsidences are common in all volcanic regions, and easily understood. But what I am now pointing out are the evidences of a former bulging-out of the earth's crust some 200 ft. to 250 ft. in this particular ocean-area. Nor do I think that any particular harm at the time was done by such a displacement of the water. The tidal wave formed by the movement would have been very serious certainly, and injurious to any native peoples then inhabiting the shores of the ocean near this area, but I doubt whether the peoples surrounding the Indian or Atlantic Oceans would have been much affected by it.

Mr. J. P. Russell, of Wangaimoana, Palliser Bay, New Zealand, pointed me out the spot where an anvil of his had been carried up by the tidal wave (caused by the earthquake here in 1854) some 30 ft. above high-water mark. I dare say

an earthquake such as that of 1854 would form as big a tidal wave as the great and general former upheaval I refer to in the islands of the Pacific.

In the boat-cove at the entrance to Vavau Harbour I saw fractures in the coral caused by upheaval, but these may only have been local. The terraces at Cape Quiros, in Espiritu Santo (New Hebrides), should be counted, as these terraces may represent successive upheavals.

The following is the account of the Tacoma disaster: "More complete details relative to the Tacoma disaster are given in a Reuter's telegram dated Tacoma, Washington, 29th November. A mysterious accident which resulted in great damage to property occurred here last night. At 11 o'clock a loud roaring was heard, like that preceding the advance of a tidal wave, and 600 ft. of the docks suddenly disappeared into the bay. Two steamers were disabled and sunk. The ground in the vicinity subsided to the extent of 6 in. to 1 ft., causing a panic and stampede among the crowd which had collected in the vicinity. The cattle-pens of the Northern Pacific Railway, and the company's offices, besides a freight-house 1,400 ft. in length, collapsed, the last mentioned catching fire. Various theories are advanced as to the cause of the disaster. The steamboat men maintain that it was due to a tidal wave 25 ft. in height, while others assert that, owing to a submarine land-slide, a great fissure or hole was formed beneath the bay, causing the docks to be swallowed up. Two lives were lost."

I ought, perhaps, now to refer to Easter Island. We all know of the stone images there, 5 ft. to 37 ft. high, but usually 15 ft. to 18 ft. These are all cut out of a grey compact lava found in the crater of Hotuiti, at the east end of the island, where there are still many in an unfinished state. Their shape is the human trunk, terminating at the hips, the arms close to the sides, the hands sculptured in low relief, and clasping the hips. The head is flat, and the top of the forehead cut off level, so as to allow the crown, which is made of red tuff (found in the Te Rano Kao crater), to be put on. The face is square, massive, and sternly disdainful in expression, the aspect always upwards. Easter Island is volcanic, and has numerous extinct craters rising from different parts of the island, none of which have been active for a long time. The red tuff found in the Te Rano crater, from which the crown of the images are made, shows previous submarine volcanic origin; calc. tuff—which I suppose this red tuff to mean—being a mineral nearly identical with limestone and marble. The statement of the present inhabitants of Easter Island that their ancestors cut these images need not be credited. As already mentioned, my opinion is that the images were cut

by a race of people previous to the special local migration of the present inhabitants. I know of no race of islanders in the Pacific now acquainted with sculpture; neither do they possess even the tools with which they could do the work.

There is an exception, perhaps, to these two statements—viz., the arragonite money of Uap (or Yap), in the Carolines, and the Spaniards may have taught some of the Western Pacific islanders, since the sixteenth century, to roughly carve in coral. But the extraordinary money mentioned is composed of large discs of arragonite, often of great size; 6 ft. in diameter, 12 in. thick, and about 3 tons in weight are not uncommon dimensions. It is not used as a medium of exchange, but for purposes of ostentation. The arragonite is brought from a quarry in the Harbour of Malakal, at Korror Island, in the Palao or Pelew Group.

At the Duke of York and New Britain Islands it was the custom for a chief to place all his treasures before a visitor, and after inspection to have them put away. Thus several large coils of cowry money, about the size of lifebuoys, were placed before the Rev. Messrs. Brown and Fletcher at Blanche Bay when opening the first mission to those islands in 1875. These islands are about thirteen hundred miles from Uap, not an excessive distance for a canoe voyage in the Pacific. It would be well if some officer of our warships visiting the Carolines would inform us how this arragonite money is cut and removed from the quarry.

The trinolith and Langiis at Tongatabu (of which I present photographs) were cut from the coral reef, I believe, as the stones are not far from shore. (I am waiting Mr. A. W. Mackay's paper for a full and minute description of these ruins.) Arragonite is a mineral essentially consisting of carbonate of lime, and much like calcareous spar. The two minerals only differ in their form of crystallization. The rhombic prisms of arragonite are easily divided by the hammer, so that there should be little difficulty in quarrying them. Arragonite is a mineral found usually in volcanic districts, and in the neighbourhood of hot springs. Its crystals are sometimes prisms shortened into tables, which this money resembles. It appears to be the product of a crystallization taking place at a higher temperature than that in which calcareous spar is produced, showing great submarine volcanic action in days gone by at Uap. I should consider that the coral-polyp first deposited the lime, great subsidence and followed by volcanic action subsequently breaking up and converting the reef into columns of basalt, calcareous spar, and arragonite.

Mr. F. J. Moss, in his book, "Through Atolls and Islands in the Great South Sea," writes of Ponape (or Ascension

Island, the largest of the Seniavine Group in the Carolines) and its neighbouring islets "as being a number of volcanic islands varying in size, representing the mountain-tops of an ancient land," quite forgetting that the basaltic columns of which the ruins at Ponape are composed are really a variety of volcanic lava formed from lime. The ancient mountains must first of all have the lime deposited upon them, then have been subjected to great volcanic action, which melted them, and afterwards threw them up from the sea. Evidences show that these islands are now sinking again, which looks to me as if the bed of the Pacific ever since the globe cooled has been the seat of a constant and steady deposit of lime and subsequent great volcanic action, including upheaval and subsidence.

I might mention here that Ponape itself rises some 2,860 ft., its shores and hillsides strewn with loose blocks of basalt, many of them perfect hexagonal prisms of considerable size. Mr. Moss considers its summit "as probably to have formed the backbone of an ancient great mountain-range of the submerged continent." I refer members to his interesting work. Yet he tells us "that so thickly is the place strewn, so numerous are the basaltic blocks, and so extensive an area do they cover, that it looks as if the whole island had been at one time terraced and cultivated, and that these rocks and prisms are the ruins of the terraces washed or fallen from the hills to the shore below." But the basaltic columns forming the walls of the great temple ruin at Ponape show little or no wear from water. Their rhomboids and angles are still intact, which makes me think that the volcanic action was submarine, and that subsequent upheaval tumbled the columns and broke them up as they now are found. Moreover, the particular islet upon which this great temple is found, like many of the other islets near it, is embanked with massive walls of the same style as the building. "These careful embankments, the great walls, and the solemn silence gave to the whole the appearance of a city dead and deserted now, but with canals once crowded with canoes filled with devotees eager to attend the savage rites and sacrifices of which the ruined mass before us may have been the sacred scene." Ancient Mexican history and rites are recalled to mind by this extract. The embankments forming these canals show that the sea was encroaching when they were built. Also the fact that the canals are still wadable shows either that they could not have been embanked so many centuries ago or the extreme stationary condition of sea- and land-level for the past 3,500 years in that locality.

There is little doubt to my mind that colonies from ancient Mexico and Peru voyaged westward into the Pacific and left

traces of their handiwork at Easter Island and on Tonga. The Carolines doubtless were colonised from Asia.*

Again, Mr. Moss says, "The rude character of the structures is apparent. Not a vestige of art or workmanship of any kind is to be seen." Now, the Langiis at Tongatabu show sculpture, as do the images at Easter Island.

At Tele, forming one of the Ualau or Strong Island Group (Ualau rises 2,000 ft., and is a basaltic island), are similar interesting ruins built of enormous blocks of basalt, showing that the people who shifted them about knew how to handle great weights, like the pyramid-builders in Mexico, Peru, and Egypt, and those who erected the stone ruins we find at Stonehenge or in northern France.

There are also several artificial canals and a canoe-harbour at Tele. These artificial canals show an acquaintance with the ancient canal system of Mexico and Peru, and that the migration of people who built them may have come direct from America. The ruins in Tele are stated by the natives to have been built by the former inhabitants partly for their defence and partly in honour of the dead, the large blocks of stone being brought from the main island on rafts. This, again, shows an acquaintance with the manner the red-granite blocks of Syene in Upper Egypt were anciently rafted down the river to Lower Egypt in flood-time, also with the way the Assyrians rafted great weights down their rivers. I do not think the present inhabitants of any of the Carolines know how to remove these heavy weights. A great weight is sometimes moved in the islands by rolling or pushing it into deep water, lifting it and fastening it under two strong canoes, and then sailing or paddling it to any required distant point. But this, again, only proves an acquaintance with ancient raft-movement, as it were.

Captain C. A. Bridge, of H.M.S. "Espiègle," read an excellent paper, I believe, upon these ruins before the Royal Society, but I have not seen it. All that I wish to show is the part played by volcanic action in their origin.

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* We really have to go back at least to the pyramid-builders (3,500 years ago) to reach an age where the people executed such works as we find at Tongatabu, Easter Island, and the Carolines. The latter, however, appear to be rude and cyclopean, another proof of the lapse of the thirty-five centuries of human time. Geological time (millions of years) I am not referring to at all, as my task is only to record the surface facts as I find them now in the Pacific. If the coral-polyp is nature's scavenger, and keeps the waters of the ocean pure by extracting the excess of lime within equatorial limits, fixing it there in the form of coral reefs, there must, I suppose, be some method of redistribution or the equatorial regions would soon be all lime. Upheaval and subsidence resulting from great volcanic action may be the methods nature employs to melt and redistribute this excess of lime and keep everything equal on the planet.

The Hogulu group of islands, in the Carolines, is composed of ten lofty basaltic islands and numerous coral islands enclosed in a vast lagoon like a large lake in the sea. Yap, or Uap, or Guap is also of volcanic origin.

Asking pardon for this digression, I now proceed onwards to the eastern Pacific, so as to finish this portion of my subject.

Some of the Paumotus are rising, some sinking, some in a state of rest. Henderson Island is 80 ft. high. Pitcairn and the Gambiers rise to 1,000 ft. Osnaburg Island appears to have changed since 1790 from a "reef of sunken rocks" to an island fourteen miles long; whilst Archangel Island (20° 29′ S.) appears to have sunk out of sight since 1606. Actual volcanic action is most peculiar. It really appears to delight in confining itself (in the one given line) to one spot or pipe at a time, striking a blow or thump from below to "knock out," as it were, one identical spot; which, if weak enough, "gives" to the imprisoned giant, and we have an elevation or a crater. At sea this thump from below strikes a vessel as if she had gone crash upon a rock. Quite recently a vessel sailing from San Francisco to Japan met with such an experience in the northern Pacific, and it made the crew dazed and sick. The greater the pressure of water the more the imprisoned giant likes to assert itself; but directly it meets with no resistance it acts quite gently, and expands its force in slight elevations above the sea. But I regard volcanic phenomena as the great ultimate friend of man, notwithstanding any immediate damage they may do.

Many of these Paumotu Islands descend sheer 1,500 ft. to 4,000 ft. within 1,000 yards of the reef. Aurora Island (15° 48′ S.) is an uplifted coral island about 230 ft. high, with the usual perpendicular sides found all along this line, and nowhere else that I know of on the planet except in Possession Island, in the Antarctic, where Sir James C. Ross landed in 1841. The Tongan Islets are positively square, having flat tops and straight sides. Of course, there are many coasts with perpendicular cliffs, but what I wish to say is that these straight-up-and-down islands show upheaval, and not subsidence.

Of course, a vast deal of geological work is required to be done in the Pacific, now the very home of volcanic activity, as it were, of this planet—here and in the antarctic region. In Appendix B I give a brief account of the antarctic volcanoes from a paper by Captain Borchgrevinck, in order that all the information I can collect of volcanic action within the sphere of the Pacific Ocean, as it were, may be collected in one paper for the use of future observers.

The Marquesas lie nine hundred miles to the north-east of

the Society Islands, nearly midway between them and the equator, being situated between the parallels of 8° and 11° S. and the meridians of 138° and 141° W. They have a warmer climate than Tahiti, and are all mountainous and volcanic, rising to upwards of 5,000 ft. above the sea (Magdalene, 3,675 ft.; Santa Christina, 3,280 ft.; Adams Island, 4,042 ft.; and Masse Island, 2,000 ft. high). The mountain-peaks are extremely broken and rugged, and the centres of some of the islands are occupied by piles of rocks of most fantastic shape. The volcanic precipices in many places extend abruptly down to the sea, presenting barren walls of black and naked lava; but the intermediate valleys are singularly fertile and picturesque, and are copiously watered by streams which descend in numerous cascades, one of which (in Nukahiva) is 2,000 ft. high, and is amongst the most beautiful in the world. They have no active volcanoes, and do not appear to be subject to earthquakes.

From Angas's "Polynesia" I also extract certain remarks upon active volcanoes in the Pacific; also an extract from Miss Bird's "Hawaiian Archipelago" (see Appendix A).

I refer briefly to the Sandwich Islands. On the 24th February, 1877, a slight shock of earthquake was felt at Kaavoloa, Hawaii, and steam was observed to be rising from the sea off Cocoanut Point. On visiting the spot it was found that lumps of porous lava, some nearly a cubic foot in size, were rising to the surface, when, on the contained gas escaping, they sank again. At the time of the earthquake a crack opened in the ground from Cocoanut Point in an east-south-east direction, extending for more than a mile, in some places 4 in. broad and 50 ft. deep. (This, again, shows the east-south-east trend. I have sometimes in this paper referred to the trend as south-east and north-west: I believe I should be more correct in saying east-south-east and west-north-west.)

Mauna Haleakala, on the Island of Maui, is somewhat like Mauna Kei, in Hawaii. The craters upon it are inactive, the natives having no tradition of any eruption.

Space does not permit me to refer to the phenomena in the various other islands of the Sandwich Group. Oahu (on which is Honolulu) is the principal island of the group, and the extensive plain on which that city stands is purely volcanic. About three miles north-west of Honolulu there is a remarkable circular salt-water lake, about half a mile in diameter, so impregnated with salt that twice every year the natives take out large quantities of fine, hard, clear, crystallized salt, which furnishes a very valuable article of commerce. At the time of the visit of the United States Exploring Expedition it was believed by the natives to be fathomless, but on examination by Commodore Wilkes it proved to be only

18 ft. deep. I mention this now as I have often heard of other lakes in the Pacific believed by the natives to be similarly fathomless.

It will be noticed that the Sandwich Island volcanoes are quite outside of my three lines of phenomena. But Kilauea may only be a huge safety-valve in this particular portion of the earth's crust, showing a great and permanent fault near it. That it has long been so the immense height of the volcanic lava, cinder, and ash heap forming the mountain (nearly 32,000 ft.), with a base of a hundred miles in diameter, proves; so that this safety-valve must have retained this one escape for many thousands of years; or it may be that the whole bed of the ocean for more than a thousand miles round the group has been slowly subsiding, and that the volcanoes on the Sandwich Group, and Cotopaxi and others in Central America, are safety-valves. Certainly the islands in the Pacific on and immediately to the north of the equator, as I have pointed out, have been also slowly subsiding. The result of this subsidence has been upheaval along the 20th parallel of south latitude, as the evidences show.

I might also point out that the trend of the Sandwich Group, south-east to north-west, somewhat contradicts my theory of islands north of the equator trending south-west to north-east, like the Japan, Kurile, and Aleutian Islands.

I am particular in giving members all the information I can upon this subject, principally in the southern Pacific (without making detailed reference to the New Zealand craters, which more able observers have described), so that the heights and distances of the various active and extinct volcanoes from each other may be seen almost at a glance by any persons studying the map of the ocean. It would be necessary to examine the records taken by the "Challenger" and other expeditions as to the depths of the Pacific Ocean between the different groups of islands. It is a mistake to suppose that there are vast stretches of ocean-bed between these groups, because that is not generally the case by any means. For the fixity of all the continents and oceans; the limitation of the supposed great glacial epochs and ice regions almost to their present position; the fixity of the poles and the equator from the original setting of the planet after cooling to the positions we find them now, would follow as corollaries to my present doubt of the former existence of a great southern continent in the Pacific. But why the shores of the Pacific Ocean and its central southern bed should be subject to so much volcanic action is remarkable. We find few such phenomena around the shores of the Atlantic or Indian Oceans. The fact that active volcanoes are confined within a short distance of sea-coasts might show a weakness in the

crust of the earth where the great sea-beds join the continents. But I do not see how this weakness could extend right across the arch in the crust of the earth under the great sea-beds from 40° S. latitude to 50° N. latitude, yet it is known that the great earthquake of Lisbon in 1755 did shake such an arch of the earth's crust over an area of 700,000 miles.

This, however, is a question to be hereafter considered. My present task is to set down the actual facts as I find them in the Pacific. I have thought it right to add to the two lines of volcanic action I first purposed pointing out the line of upheaval along the 20th parallel of south latitude, from the Loyalty Islands to the Cook Group, as well as the other facts collected. I have not seen them specially referred to by any other observer before. Huge active volcanoes exist in Central America, the Sandwich Islands, Vulcan Island, and New Guinea. With Mount Hecla near the North Pole, and Mounts Erebus and Terror (and other active volcanoes in Graham Land) near the South Pole, the Pacific volcanoes, with Vesuvius and Etna in the Mediterranean, are nearly the only great safety-valves the planet now possesses. Evidences of extinct volcanoes are abundant, but these are now far removed from sea-water.

The matter has its practical side, too, seeing that the market need never be short of sulphur whilst there are such great deposits of that mineral in Tanna or Ambrym in the New Hebrides, or at the Mother and Two Daughters in New Ireland, &c. The cultivators of the grape-vine in Australia use hundreds of tons of sulphur. They will find plenty in the different spots I have named.

Our own White Island, off Poverty Bay, is still in a state of volcanic activity, and must be regarded as the summit of a crater but little elevated above the sea. It emits from time to time volumes of white smoke. It produces, as I have said, a great quantity of sulphur. Several cargoes have been sent to Europe, and realised £8 a ton. It is very pure, containing 90 per cent.

The intermittent action of volcanic energy referred to is noticed in nearly all active volcanoes and geysers. It is very marked at Tanna, and in some of our New Zealand geyser-fountains the discharge is very regular as to time. There is, indeed, one geyser in our hot-lake district so regular in its discharge that I think it is called the "twelve-minute geyser" (eight to ten minutes at Tanna, and ten to fifteen minutes at Ambrym).

The crater at Cotopaxi is situated in latitude 0° 41′ S. and longitude 78° 42′ W., at a height of 19,493 ft. above the present level of the Pacific Ocean, showing that once a safety-valve is formed the internal fires keep as much as possible to

the one pipe. Extinct volcanic areas may therefore be regarded as practically done and finished with, having performed their part in the economy of the planet.

The earth, perhaps, does not require so many safety-valves now as formerly, and volcanoes will gradually lessen in number. From their present number (270 to 300) it will take, I should think, many million years for their activity to cease; for it is evident that, as it has taken so long a period of time for the extinct volcanoes to assist in the formation of the fixed continents, a similar period may be granted to the present active cones to perform their work and die. Sea-water is doubtless the primary cause of volcanic activity, but there has also to be taken into account the slight annual shrinking of the planet itself, forcing to the surface a small amount of inner material in the form of lava, dust, pumice, and volcanic ash.

APPENDIX A.

The Sandwich Islands Phenomena.

The largest and most important burning mountains at present in a state of activity in the Polynesian Islands are those which occur in the Sandwich Group. One of these, the volcano of Kirauea (Kilauea), in the Island of Hawaii, is especially worthy of notice. Indeed, the whole island, covering a space of four thousand square miles, from the summits of its lofty and snow-clad mountains, some 14,000 ft. above the sea, down to the beach, is, according to the observations of geologists, one complete mass of lava and other volcano substances in different stages of decomposition. Perforated with innumerable apertures in the shape of craters, the island forms a hollow cone over one vast furnace, situated in the heart of a stupendous submarine mountain, rising from the bottom of the sea.

The great volcano of Kirauea, or Kireueanui (Kilauea) as it is called by the Sandwich Islanders, is situated about twenty-five miles inland from the south-east coast of Hawaii, and nearly equidistant between the two great mountains called Mauna Kea and Mauna Roa, the elevation of the former of which is estimated to be 13,645 ft., whilst that of the latter exceeds 14,000 ft. This crater was first visited and described by the Rev. W. Ellis, who made the ascent in 1823. In his graphic and interesting narrative he thus describes the scene presented to his view on reaching the edge of the great crater, after a toilsome ascent through regions of lava and volcanic sand: "About 2 p.m. the crater of Kirauea suddenly burst upon our view. We expected to have seen a mountain with a broad base and rough indented sides, composed of

loose slags or hardened streams of lava, and whose summit would have presented a rugged wall of scoria, forming the rim of a mighty cauldron; but instead of this we found ourselves on the edge of a steep precipice, with a vast plain before us, fifteen or sixteen miles in circumference, and sunk from 200 ft. to 400 ft. below its original level. The surface of this plain was uneven, and strewed over with large stones and volcanic rocks, and in the centre of it was the great crater, at a distance of about a mile and a half from the walls of the precipice on which we were standing. Our guides led us round towards the north end of the ridge, in order to find a place by which we might descend to the plain below. The steep down which we scrambled was formed of volcanic matter, apparently a light-red and grey kind of lava, vesicular, and lying in horizontal strata, varying from 1 ft. to 40 ft. in thickness. In a small number of places the different strata of lava were also rent in perpendicular or oblique directions from the top to the bottom, either by earthquakes or other violent convulsions of the ground connected with the action of the adjacent volcano. After walking some distance over the sunken plain, which in several places sounded hollow under our feet, we at length came to the edge of the great crater itself, where a spectacle sublime and even appalling presented itself before us. Immediately before us yawned an immense gulf, in the form of a crescent, about two miles in length, from north-east to south-west, nearly a mile in width, and apparently 800 ft. deep. The bottom was covered with lava, and the south-western and northern parts of it were one vast flood of burning matter, in a state of terrific ebullition, rolling to and fro its fiery surge and flaming billows. Fifty-one conical islands, so to speak, of varied form and size, containing so many craters, rose either round the edge or the surface of the burning lake. Twenty-two of them constantly emitted columns of grey smoke or pyramids of brilliant flame; and several of these at the same time vomited from their ignited mouths streams of lava, which rolled in blazing torrents down their black indented sides into the boiling mass below. The grey and calcined sides of the huge crater before us; the fissures which intersected the surface of the plain on which we were standing; the long banks of yellow sulphur on the opposite side of the abyss; the vigorous action of the numerous small craters on its borders; the dense columns of vapour and smoke that rose at the north and south ends of the plain; together with the ridge of steep rocks by which it was surrounded, rising probably, in some places, 300 ft. or 400 ft. in perpendicular height, presented an immense volcanic panorama, the effect of which was greatly augmented by the constant roaring of the vast furnaces below." At night the grandeur of the scene

reached its climax. "The dark clouds and heavy fog that after sunset had settled over the volcano gradually cleared away, and the fires of Kirauea, darting their fierce light athwart the midnight gloom, unfolded a sight terrible and sublime beyond all we had seen. The agitated mass of liquid lava, like a flood of melted metal, raged with tumultuous whirl. The lively flame that danced over its undulating surface, tinged with sulphurous blue or glowing with mineral red, cast a broad glare of dazzling light on the indented sides of the insulated craters, whose roaring mouths, amidst rising flames and eddying streams of fire, shot up at intervals, with very loud detonations, spherical masses of fusing lava or bright ignited stones. The dark, bold outline of the perpendicular and jutting rocks around formed a striking contrast with the luminous lake below, whose vivid rays, thrown on the rugged promontories and reflected by the overhanging clouds, combined to complete the awful grandeur of the scene."

From Miss Bird's "Hawaiian Archipelago" I extract the following description of the great lava-flow of Kilauea of the 2nd April, 1868 (I think it only right to include it here): "I could fill many sheets with what I have heard, but must content myself with telling you very little. In 1855 the fourth recorded eruption of Mauna Loa occurred. The lava flowed directly Hilo-wards, and for several months, spreading through the dense forests which belt the mountain, crept slowly shorewards, threatening this beautiful portion of Hawaii with the fate of the cities of the plain. Mr. C. made several visits to the eruption, and on each return the simple people asked how much longer it would last. For five months they watched the inundation, which came a little nearer every day. Should they fly or not? Would their beautiful homes become a waste of jagged lava and black sand, like the neighbouring district of Puna, once as fair as Hilo? Such questions suggested themselves as they nightly watched the nearing glare, till the fiery waves met with obstacles which piled them up in hillocks, eight miles from Hilo, and the suspense was over. Only gigantic causes can account for the gigantic phenomena of this lava-flow. The eruption travelled forty miles in a straight line, or sixty including sinuosities. It was from one to three miles broad, and from 5 ft. to 200 ft. deep, according to the contours of the mountain-slopes over which it flowed. It lasted for thirteen months, pouring out a torrent of lava which covered nearly three hundred square miles of land, and whose volume was estimated at 38,000,000,000 cubic feet! In 1859 lava-fountains 400 ft. in height, and with nearly equal diameter, played on the summit of Mauna Loa. This eruption ran fifty miles to the sea in eight days,

but the flow lasted much longer, and added a new promontory to Hawaii. These magnificent overflows, however threatening, had done little damage to cultivated regions, and none to human life; and people began to think that the volcano was reformed. But in 1868 terrors occurred which are without precedent in island history. While Mrs. L. was giving me the narrative in her graphic but simple way, and the sweet wind rustled through the palms, and brought the rich scent of the ginger-plant into the shaded room, she seemed to be telling me some weird tale of another world. On the 27th March (five years ago) a series of earthquakes began, and became more startling from day to day, until their succession became so rapid that 'the island quivered like the lid of a boiling pot nearly all the time between the heavier shocks. The trembling was like that of a ship struck by a heavy wave.' Then the terminal crater of Mauna Loa (Mokuaweoweo) sent up columns of smoke, steam, and red light; and it was shortly seen that the southern slope of its dome had been rent, and that four separate rivers of molten stone were pouring out of as many rents, and were flowing down the mountain-sides in diverging lines. Suddenly the rivers were arrested, and the blue mountain-dome appeared against the blue sky without an indication of fire, steam, or smoke. Hilo was much agitated by the sudden lull. No one was deceived into security, for it was certain that the strangely pent-up fires must make themselves felt. The earthquakes became nearly continuous; scarcely an appreciable interval occurred between them; the throbbing, jerking, and quivering motions grew more positive, intense, and sharp; they were vertical, rotary, lateral, and undulating, producing nausea, vertigo, and vomiting. Late in the afternoon of a lovely day, 2nd April, the climax came. 'The crust of the earth rose and sank like the sea in a storm.' Rocks were rent, mountains fell, buildings and their contents were shattered, trees swayed like reeds, animals were scared and ran about demented, men thought the judgment had come. The earth opened in thousands of places, the roads in Hilo cracked open, horses and their riders and people afoot were thrown violently to the ground; 'it seemed as if the rocky ribs of the mountains and the granite walls and pillars of the earth were breaking up.' At Kilauea the shocks were as frequent as the ticking of a watch. In Kau, south of Hilo, they counted three hundred shocks on this direful day; and Mrs. L.'s son, who was in that district at the time, says that the earth swayed to and fro, north and south, then east and west, then round and round, up and down in every imaginable direction, everything crashing about them, 'and the trees thrashing as if torn by a strong rushing wind.'

He and others sat on the ground bracing themselves with hands and feet to avoid being rolled over. They saw an avalanche of red earth, which they supposed to be lava, burst from the mountain-side, throwing rocks high into the air, swallowing up houses, trees, men, and animals, and travelling three miles in as many minutes, burying a hamlet with thirty-one inhabitants and five hundred head of cattle. The people of the valleys fled to the mountains, which themselves were splitting in all directions, and, collecting on an elevated spot, with the earth reeling under them, they spent the night of the 2nd April in prayer and singing. Looking towards the shore, they saw it sink, and at the same moment a wave, whose height was estimated at from 40 ft. to 60 ft., hurled itself upon the coast and receded five times, destroying whole villages, and even strong stone houses, with a touch, and engulfing for ever forty-six people who had lingered too near the shore. Still the earthquake continued, and still the volcano gave no sign. The nerves of many people gave way in these fearful days. Some tried to get away to Honolulu; others kept horses saddled on which to fly, they knew not whither. The hourly question was, What of the volcano? People put their ears to the quivering ground and heard, or thought they heard, the surgings of the imprisoned lava-sea rending its way among the ribs of the earth. Five days after the destructive earthquake of the 2nd April the ground south of Hilo burst open with a crash and roar which at once answered all questions concerning the volcano. The molten river, after travelling underground twenty miles, emerged through a fissure two miles in length with a tremendous force and volume. It was in a pleasant pastoral region, supposed to be at rest for ever, at the top of a grass-covered plateau covered with native and foreign houses, and rich in herds of cattle. Four huge fountains boiled up with terrific fury, throwing crimson lava, and rocks weighing many tons, to a height of from 500 ft. to 1,000 ft. Mr. Whitney, of Honolulu, who was near the spot, says, 'From these great fountains to the sea flowed a rapid stream of red lava, rolling, rushing, and tumbling like a swollen river, bearing along in its current large rocks that made the lava foam as it dashed down the precipice and through the valley into the sea, surging and roaring throughout its length like a cataract, with a power and fury perfectly indescribable. It was nothing else than a river of fire from 200 ft. to 800 ft. wide and 20 ft. deep, with a speed varying from ten to twenty-five miles an hour.' This same intelligent observer noticed as a peculiarity of the spouting that the lava was ejected by a rotary motion, and in the air both lava and stones always rotated towards the south. At Kilauea I noticed that the lava was ejected in a southerly direction.

From the scene of these fire-fountains, whose united length was about a mile, the river in its rush to the sea divided itself into four streams, between which it shut up men and beasts. One stream hurried to the sea in four hours, but the others took two days to travel ten miles. The aggregate width was a mile and a half. Where it entered the sea it extended the coast-line half a mile, but this worthless accession to Hawaiian acreage was dearly purchased by the loss, for ages at least, of 4,000 acres of valuable pasture land, and a much larger quantity of magnificent forest. The whole east snore of Hawaii sank from 4 ft. to 6 ft., which involved the destruction of several hamlets and the beautiful fringe of cocoanut-trees. Though the region was very thinly peopled, two hundred houses and a hundred lives were sacrificed in this week of horrors; and from the reeling mountains, the uplifted ocean, the fiery inundation, the terrified survivors fled into Hilo, each with a tale of woe and loss. The number of shocks of earthquake counted was two thousand in two weeks, an average of a hundred and forty a day; but on the other side of the island the number was incalculable."

Appendix B.

Extracts from a Paper by Captain C. G. Borchgrevinck.

Already the first sight of Victoria Land convinces one that it is of volcanic origin. The volcanoes of Victoria Land show a tendency to follow the same line. From Mount Sabine to Mount Melbourne the trend is south-south-westerly. Mount Erebus and Mount Terror lie almost due south of Mount Sabine. Further north from Mount Sabine the great earth-fold, on the septum of which this chain of volcanoes is situated, probably bends a little westward, as shown partly by the surroundings partly by the position of Balleny Island. North-west of Balleny Islands the great fold trends perhaps to the knotting-point between the Tasmanian axis of folding and that of New Zealand, the former perhaps running through Royal Company Island and Macquarie Island. The knotting-point would probably be somewhere (approximately) near the intersection of the 60th parallel of south latitude, about the 150th meridian of longitude east from Greenwich. It would just join the line of extinct volcanoes along East Australia on the west, and perhaps the active volcanic zone of the North Island of New Zealand, or, at all events, the fold which bounds that continent, on the east.

Traced in the opposite direction the volcanic zone probably runs through Seal Islands, the active volcanoes of

Christensen and Sarsee, and through Mount Haddington, an extinct volcano in Trinity Land, to Paulet and Bridgman Islands' active volcanoes. The volcanic zone bends easterly from here on account of the easterly trend in the fold, which appears to make a loop towards South Georgia before it swings back towards Cape Horn. That there is a real easterly trend in the earth-fold at Trinity Land and the South Shetlands is proved by the observations made by the "Astrolabe" and "Zélée" expedition, which record a strike in a north-north-east and south-south-west direction to the greyish-white limestones and phyllite-schists at the South Orkneys. Toward Cape Horn from near South Georgia the fold probably trends west-north-westerly, then follows an approximately meridional direction parallel with the chain of the Andes.

It may be noted, however, that, whereas the Erebus chain of Victoria Land is on the east side of the fold, the Christensen-Bridgman group are apparently on the opposite side. This may be due to the fact that at the latter locality the eastern slope of the fold is steeper than the western, as seems probable from the presence of the deep ocean abyss east of Graham Land, as shown on Dr. Murray's map. It is probable, therefore, that the volcanic chain of Victoria Land will continue towards the south pole, probably bending somewhat to the eastward, and will thence change its position to the fold on the other side of the antarctic continent, so as to run through the Christensen-Bridgman lines of volcanoes. In any case it is almost certain that high land, covered, of course, more or less by snow and glaciers, will be found at the south pole.

The honour of being the first man to discover the antarctic continent probably belongs to Captain James Cook, who, in the year 1772, reached latitude 71° 10′ S. in longitude 106° 54′ W., where he sighted the great ice-barrier which formed the seaward boundary of Antarctica. Speaking of this discovery, Sir James Clark Ross says, "I confidently believe that the enormous mass of ice which bounded his view when at his extreme south latitude was a range of mountainous land covered with snow." In 1819 William Smith, in the brig "William," discovered the archipelago of the South Shetlands, south of Cape Horn. In 1820–23 Weddell visited the South Shetlands, including the active volcano Bridgman. Powell, the discoverer of the South Orkneys, visited the volcanic island of Bridgman in 1882, and found it to be at that time 200 ft. high. Weddell, who visited it during the following year, estimates its height at 400 ft., and describes the island as being of sugar-loaf shape, whereas at the time of Powell's visit there was a crater on the west side

of the island. Weddell penetrated to 74° S. in 1823, thus attaining a higher latitude than Captain Cook, but he saw no land anywhere in that neighbourhood. In 1831 Biscoe, in the brig "Tula," discovered Enderby Land. In 1839 Balleny discovered Balleny Islands, a volcano 12,000 ft. high, and adjoining it the active volcano of Buckle Island. In 1839 the important French expedition under Dumont D'Urville explored the South Shetlands. In 1840 Commander Wilkes, in the U.S.A. corvette "Vincennes," discovered Wilkes Land. In January, 1841, Sir James Clark Ross made his memorable discovery of Victoria Land. With the object of trying to find the south magnetic pole, as he had already found the north magnetic pole, he forced his well-fortified ships through the pack-ice which he encountered in latitude about 67° S., and longitude 174½° E. It was a very formidable pack. In four or five days, however, he forced his way through it, and entered comparatively open water —being a great ocean-pool about six hundred miles in diameter. Bounding this on the west was the magnificent chain of snow-clad volcanoes of Victoria Land. Ross traced the coast for five hundred miles southwards, until he encountered the great ice barrier terminating seawards in a sheer wall of ice from 180 ft. to 200 ft. high. His dredging showed that marine forms of animal life, especially Polyzoa, were abundant right up to the edge of the great ice barrier. Ross states that on the 19th January, 1841, when off the coast of South Victoria Land, in latitude 72° 31′ S., longitude 173° 39′ E., the dredge was put over in 270 fathoms water, and after trailing along the ground for some time was hauled in.

In 1874 H.M.S. "Challenger" visited the neighbourhood of the supposed Termination Land of Wilkes. In 1893–94 the whaler "Jason," with Captain Larsen, visited the north-western portion of Antarctica.

The important discovery was made by Dr. Donald of Lower Tertiary rocks within the fossil shells—*Cucullæa, Natica,* and *Cytherea, in sitû*—at Cape Seymour. Fossil wood was found imbedded in the Tertiary rocks at a level of 300 ft. above the sea. A new active volcano, named by Captain Larsen "Christensen Volcano," was discovered in latitude 65° 5′, longitude 58° 40′ W. On the sketch-chart accompanying Captain Larsen's paper another active volcano is shown also, Windberg Volcano, and the four Seal Islands, all of which are considered to be of volcanic origin, if not dormant or extinct volcanoes.

ART. XXIV.—*Castle Rock, Coromandel.*

By J. M. MACLAREN.

[*Read before the Auckland Institute, 28th August, 1899.*]

THE subject of these few notes will be readily recalled to mind by those who have had occasion to travel within sight of the northern portion of the Cape Colville Peninsula. The abrupt manner in which this peak rises from the main range, and its extremely castellated appearance, tend to make it the most salient feature in an otherwise featureless landscape. Situated some five miles south-east of Coromandel Township, and in a low saddle on the main range, here 1,250 ft. in height, it reaches an altitude of 1,724 ft., a height insignificant in itself, but sufficiently striking when the last 400 ft. of ascent is sheer on three sides.

To the casual observer the appearance of the peak probably conveys a suggestion of Titanic agencies that, in another quarter of the globe, have once again attempted to pile Ossa on Pelion. And, indeed, it must have been a mighty convulsion of nature that heralded its appearance; but at the same time it is to be remembered that the present form of the rock is not that which it assumed at its birth, but that into which it has been moulded by the action, during the ages, of the sculpturing-chisels of nature—the rain and the winds.

Though notable in itself, Castle Rock is much more interesting as being the most prominent feature of an extrusion of igneous matter that extended for miles across the country, from north-west to south-east, breaking indiscriminately through Palæozoic slates and slaty shales and Tertiary andesitic lavas and tuffs. Its most northern extremity is at Kikowhakarere Bay, to the north-west of Coromandel, from whence it crosses into the township, being met with in the Kathleen Crown and Blagrove's Freehold Mines. Here also is a lava-flow that probably issued from the fissure, flowing to the west, and covering the older andesites in the Kathleen Mine to a depth of 158 ft. Further to the south-east the dyke is obscured by thick Pleistocene alluvial deposits, but reappears on the low foot-hill north of the Tiki Creek at an altitude of 550 ft. In the bed of the Tiki Creek the characteristic grey hornblende trachyte appears about half a mile beyond the sawmill, and then, still pursuing its south-east course, crosses the Pukewhau Track at an elevation of 770 ft., and is here about 2 chains wide. It next reappears on the main range as a knoll 1,250 ft. above sea-level, and a mile further to

the south-east culminates in Castle Rock, 1,724 ft. in height. From the top of this peak the southern prolongation may be traced for several miles. Exactly how far south the dyke reaches I cannot say, the only satisfaction derived from an attempt to solve this question being that of spending a miserably wet night in the bush. This much is, however, certain: that the dyke extends in a fairly straight line for nine miles, and may possibly reach to Sugar-loaf Hill, in the Waiwawa Creek, a distance of fourteen miles from Kikowhakarere Bay.

The life-history of Castle Rock, or Motutere, to use the more euphonious native name, may be here briefly sketched. It owes its birth to the same agency that covered the whole of the Hauraki Peninsula area with its immense deposit of igneous rocks—viz., the folding of the Palæozoic slates in a direction parallel to the protaxis of New Zealand. From the concomitant line of weakness welled forth immense flows of lava similar to, but lesser in degree than, those of the Hawaiian Islands at the present day. After the deposition of the Upper Eocene andesites a period of quiescence ensued, to be broken in Miocene times by volcanic outbursts at Coromandel, and on the east coast from Port Charles to Whangapoua. That these outbursts were very different in character from preceding eruptions is clear from the nature of the ejecta, and from the numerous dykes that everywhere radiate from the foci of eruption. For both the breccias and the dykes of this period indicate a superabundance of steam, in the former case by the propulsion of *débris* from a crater, and in the latter case by the rending and fissuring of the adjacent rock.

In the case of the Castle Rock dyke, the centre of eruption was probably to the west of Kikowhakarere Bay, for at the south end of this bay occur true lava-flows of an identical rock. Moreover, the coarser breccias of Beeson's Island, a little to the south, are petrologically identical with the rock of the dyke and of the lava-flow, thus pointing to a common origin.

In few places along its course does the dyke show greater resistance to the weathering agents than the enclosing rock. At Motutere itself the rock is seen to be horizontally columnar, the columns being about 10 ft. in length and 1 ft. to 2 ft. in diameter. Additional evidence in favour of slow local cooling is furnished by the superior hardness and porphyritic nature of the rock at this place.

In hand specimens the rock is grey, with large porphyritic hornblende and feldspar crystals. The specific gravity is about 2·6. Under the microscope the base is seen to be feldsitic, apparently the result of devitrification. The feldspars are both plagioclase and orthoclase, the former

perhaps predominating. Length, up to 2 mm. Carlsbad twins are common among the orthoclase feldspars. Plagioclase feldspars twinned polysynthetically, but not numerously. Amphiboles, light-green and porphyritic, reaching to 10 mm. in length. Many show strong resorption borders. Magnetite common. Free quartz sparingly present. The following is the determination by chemical analysis :—

SiO_2	58·50	per cent.
FeO	17·67	"
Al_2O_3	5·64	"
CaO	3·86	"
MgO	1·09	"
K_2O	7·22	"
Na_2O	4·17	"
Loss on ignition, &c. ...	1·60	"
	99·75	"

From the above characteristics, I have named the rock a hornblende trachyte, but it must be confessed that it stands petrologically on the border-line between trachytes and andesites.

Before concluding these notes I take the opportunity of drawing attention to a point that, so far as I am aware, has escaped the observation of geologists who have dealt with the igneous rocks of the Hauraki Peninsula. Though the Thames andesites have often been compared with those of Transylvania, and of the Comstock region of North America, yet the closer parallel drawn between the rocks of the two abovementioned localities, and also of North Germany, has not yet been applied to the succession of igneous rocks on the Hauraki Peninsula. So struck was Von Richthofen by the almost invariable order of succession of volcanic rocks that he enunciated the following as a natural law: The first-ejected lavas in a district are the andesites. Succeeding these are trachytes; and in the final stages of eruptive action the acid rhyolite lavas and the basalts are poured forth. Now, applying this law (to which, indeed, there are many exceptions) to the rocks of the Hauráki Peninsula, we find that the first deposits were the auriferous andesites, mainly developed on the western slopes of the range. In Miocene times we have the trachytic breccias of Beeson's Island and of Port Charles, &c., typically developed in the localities named, and we have also in this period the trachyte dykes of Castle Rock and Torehine, and finally, to complete the parallel, we have in the rhyolites of Tairua and the southeastern portion of the peninsula the youngest of the volcanic rocks occurring in the area under discussion.

Art. XXV.—*Description of some New Species of Pliocene Mollusca from the Wanganui District, with Notes on other Described Species.*

By R. Murdoch.

[*Read before the Wellington Philosophical Society, 12th September, 1899.*]

Plate XX.

Ringicula uniplicata, Hutton. Plate XX., fig. 6.

Hutton, Trans. N.Z. Inst., vol. xvii., p. 313; Macleay Memorial Volume, p. 36.

It seemed desirable that this minute species should be figured, and for that purpose I am indebted to Captain Hutton for the loan of type specimen. The following descriptive note may, however, be added: Body-whorl with about eighteen delicate spiral ribs, which are wider than the grooves, the penultimate with about seven minute spirals; the two apical whorls smooth; under an inch objective the whorls are seen to be finely striate with growth-lines; columella with two plaits, the anterior much the stronger, curved and somewhat reflexed; a thick callous rib extends from the insertion of the outer lip some distance down the parietal wall; the outer lip thickened and reflexed, a few inconspicuous denticles thereon; viewed from behind the reflexed lip is seen to project considerably, and appears as a thick, smooth, rounded rib.

Type, Canterbury Museum.

Locality.—Petane.

Actæon minutissima, n. sp. Plate XX., fig. 5.

Shell minute, ovato-elongate, shining, smooth, pellucid; whorls 4, apical whorl rounded, the others very slightly convex, the outward curve from the impressed sutures a little abrupt, giving a slightly turreted aspect; body-whorl nearly twice the length of the spire; a single microscopic thread encircles the body-whorl at the periphery and a little above the sutures on the two succeeding whorls; aperture ovate, slightly oblique; columella with a single posterior fold. Length, 1·96 mm.; breadth, 0·89 mm.

Type, Wanganui Museum.

Locality.—Blue-clay cliffs, west of Wanganui Heads.

This and other minute forms were sifted from sand and blue clay by Mr. T. J. Haines. It differs from other New Zealand species in its minute size and lack of sculpture.

Trophon (Kalydon) huttonii, n. sp. Plate XX., fig. 1.

Shell small, fusiform; whorls 8½, protoconch one and a half whorls, smooth, the others spirally and longitudinally ribbed, the longitudinal ribs rounded, somewhat nodular, eleven on a whorl; the spire whorls with five or six and the body with thirteen or fourteen spiral ribs, the grooves about the same width as the ribs, with the exception of a single wide groove which encircles the spire-whorls a little above the sutures, and the body-whorl close above the aperture; the rib forming the lower margin to this wider space is grooved on its surface; the whorls are finely sculptured with transverse thin laminæ, which cross both grooves and ribs (this is well preserved in some examples, and has almost disappeared in others). Sutures with a marginal rib, indistinct in some examples; aperture broadly ovate, outer lip somewhat expanded and with several small denticles a little within the margin; columella straight and rounded, anterior canal short, curved to the left, posterior canal shallow and indistinct. Length, 16 mm.; breadth, 6·2 mm.

Type, Wanganui Museum.

Locality.—Shakespeare Cliff, Wanganui.

This beautiful little shell seems quite distinct from any New Zealand species. The wide groove encircling each whorl is a characteristic feature by which it may be readily distinguished. The species I venture to name after Captain F. W. Hutton, as a small token of appreciation for his invariable kindly assistance.

Pleurotoma gemmea, n. sp. Plate XX., fig. 9.

Shell small, fusiform; whorls 6½, strongly angled, protoconch one and a half whorls, polished, the others with eighteen to twenty small nodules on the angle (these are slightly produced below the angle, and have somewhat the appearance of very short riblets); whorls obliquely longitudinally striated, and with fine spiral lines; body-whorl biangulate, the anterior angle slight, forming a line with the insertion of the outer lip; there are about twenty-four spirals between the posterior angle and anterior end, about six of which are between the aperture and angle; the posterior of these are close together and cut the nodules into minute grains; the area above the angle concave, with several microscopic spiral lines and a small marginal rib close to the sutures; aperture oval, canal produced, gently curved, outer lip (?) imperfect. Length, 13 mm.; breadth, 5 mm.

Type, Wanganui Museum.

Locality.—Blue-clay cliffs, west of Wanganui Heads.

This shell stands nearest to *P. buchanani*, Hutton, from

which it may be distinguished by the longitudinal and spiral sculpture being much less developed, giving it a more smooth appearance.

Pleurotoma albula, Hutton, var. **subalbula**, n. var. Plate XX., fig. 2.

Shell small, fusiform; body longer than the spire; whorls 8, protoconch two whorls, smooth and polished, the third usually irregular growth-lines only; the two succeeding whorls with two spiral ribs, the anterior somewhat the stronger, and one or two spiral threads; on the next, or antepenultimate, a sutural thread gradually strengthens, forming a third rib, which on the penultimate equals in size the posterior rib; in addition to these, there are two or three spiral threads between the subcentral and posterior rib, and a like number between the latter and suture; on the body-whorl are three spiral ribs in front of the aperture, usually less distinct as they approach the outer lip, and with one or two threads in the interspaces; anterior to this are ten or eleven small spirals, somewhat irregular in size; above the sinus are seven or eight threads, two of which are slightly stronger, and in some examples form small ribs; the whorls transversely striate with growth-lines, oblique on the sinus area; aperture narrow, slightly contracted below; columella straight, somewhat callused, canal short and slightly curved, outer lip thin, sinus shallow. Length, 12 mm.; breadth, 5 mm.

Type, Wanganui Museum.

Locality.—Blue-clay cliffs, west of Wanganui Heads.

Compared with a typical example of *albula*, this shell differs in the most prominent rib not being central on the spire-whorls, but nearer to the anterior ends, the area above the sinus wider, the columella stronger, canal less produced, and by the shell in general having a stouter aspect. This and the preceding species should probably be referred to section *Surcula*.

Clathurella sinclairii, Smith. Plate XX., fig. 7.

Smith, Ann. and Mag. Nat. Hist., 1884, vol. xiv., p. 320; Tryon, Man. Conch. (1), vol. vi., p. 283, pl. xxxiv., fig. 91.

To determine this species from other nearly allied fossil forms is not always an easy matter. The example chosen for illustration is recent, and a brief description of it may not be out of place.

Shell whitish, with a narrow brown band near the posterior end of whorls, and a wider band towards the anterior end of body-whorl (some examples without colour-bands); whorls 6–6½, apical whorl smooth, the others trans-

versely ribbed, ribs slightly oblique, seventeen to nineteen on the body-whorl, becoming obsolete as they approach the anterior end, fine growth-lines on and between the ribs; the anterior end of body-whorl with ten or a dozen minute spiral striæ, and three or four on the sinus area; sutures impressed; aperture ovate-elongated, somewhat narrow and oblique; columella straight, anterior canal short, lightly curved, outer lip thin, sinus shallow. Length, 10 mm.; breadth, 4 mm.

Differs from *C. abnormis*, Hutton, in the greater number of longitudinal ribs and the whorls not angled; from other New Zealand fossil species in the spiral sculpture being limited to the anterior end of body-whorl and the few delicate lines on and above the sinus area.*

Clathurella corrugata, n. sp. Plate XX., fig. 8.

Shell small, fusiform; the body much longer than the spire; whorls 5½, protoconch one and a half whorls, polished and with spiral lines, the others with strong longitudinal ribs, ten or eleven on a whorl; these are crossed by fine spiral ribs, of which there are six or seven on the spire-whorls, the three anterior strongest, with one or two threads in the interspaces; on the body-whorl are about thirteen principal spirals, with here and there a delicate thread or two in the interspaces; at the posterior end are five or six minute irregular threads; the first three ribs above the aperture are the strongest; sutures well marked; aperture somewhat narrow, columella straight, anterior canal short and straight, outer lip thin, slightly angled above, sinus well marked. Length, 7 mm.; breadth, 3 mm.

Type, Wanganui Museum.

Locality.—Blue-clay cliffs, west of Wanganui Heads.

The example described and figured is, perhaps, not quite adult; other specimens have a length of 9·5 mm.; unfortunately, they are more or less broken, the sculpture rubbed and somewhat indistinct. From *C. abnormis*, Hutton, it may at once be distinguished by the spiral sculpture on posterior end of body-whorl; from *C. dictyota*, Hutton, in the longitudinal ribs being much stronger and the cancellated sculpture less marked. I have not seen the latter species.

Clathurella hamiltoni, Hutton.

Hutton, Trans. N.Z. Inst., vol. xvii., p. 316, pl. xviii., fig. 7; Macleay Memorial Volume, p. 52, pl. vii., fig. 35.

The examples of this species occurring in the Wanganui and Okehu formations differ from the typical forms in their smaller size—they vary in length from 6·5 mm. to 9 mm.;

* For further reference to this species, see Suter, "Revision of the New Zealand *Pleurotomidæ*," Trans. N.Z. Inst., vol. xxxi., pp. 73, 74.

also unworn specimens have fine spiral lines on the embryonic whorls. Captain Hutton informs me the typical examples from Petane have the embryonic whorls smooth, but are slightly rubbed, and the spiral sculpture probably erased.

Odostomia (Pyramis) obsoleta, n. sp. Plate XX., fig. 4.

Shell minute, ovato-elongated; whorls 5, slightly convex, the two apical smooth, the first polished, the third whorl with four and the fourth with five delicate spiral grooves, leaving a narrow smooth space at the anterior end of each whorl; body-whorl nearly twice the length of spire, with eight spiral grooves, six in front of the aperture, anteriorly without sculpture, finely longitudinally striate with growth-lines; sutures lightly impressed; aperture ovate, slightly oblique, columella gently curved, the plait indistinct, situate somewhat within the aperture; a narrow deeply impressed area in the umbilical region. Length, 2·5 mm.; breadth, 1·21 mm.

Type, Wanganui Museum.

Locality.—Blue-clay cliffs, west of the Wanganui Heads.

Of this minute species there is but a single example; it is nearly allied to *O. fasciata*, Hutton, but differs in the arrangement of the spiral sculpture.

Lacuna (?) exilis, n. sp. Plate XX., fig. 3.

Shell minute, subovate, fragile, narrowly umbilicate; whorls 5, smooth, somewhat polished, the spire-whorls rounded, the penultimate more than equals the first three in length, the body-whorl large, inflated, equals four-fifths of total length of shell, the whorls lightly transversely striated with growth-lines; sutures impressed; aperture broadly ovate, slightly oblique, outer lip thin, columella gently curved, the inner lip projecting outwards as a narrow rim, leaving, as it were, a deeply channelled suture extending from the umbilicus to the posterior end of aperture; the umbilicus small and deep, with a broad shallow groove proceeding from it to the anterior end of columella. Length, 2·5 mm.; breadth, 1·6 mm.

Type, Wanganui Museum.

Locality.—Blue-clay cliffs, west of Wanganui Heads.

It is with much hesitation I refer this minute shell to *Lacuna*, a genus known only from the Northern Pacific and Atlantic. Apart from the projecting rim-like inner lip, it is not unlike this genus, and may be included provisionally. There is but a single example, and further material may assist to determine the true position.*

* Since the above was written and read the species has been submitted to Mr. H. Suter, of Christchurch, who, with Professor Boehm, f Freiburg, regards it as a form of *Lacuna*.

Mactra scalpellum, Deshayes. Plate XX., fig. 10.

Deshayes, Proc. Zool. Soc., 1854; Reeve, Conch. Icon., fig. 106; Man. N.Z. Moll., p. 138.

I offer a figure of this somewhat rare shell. Some half-dozen examples were found in the sandy blue clays occurring in the coastal cliff north-west of the Wanganui Heads. The shell is triangular, oblong, compressed, equilateral, shining, extremities rounded, slightly attenuated, finely concentrically striated; umbones small, closely approximated; right valve with two narrow lateral teeth on each side of the cartilage-pit, and one on each side in the left valve; pallial sinus deep, rounded at the apex. The specimen figured has a length of 21 mm., and a breadth of 12·5 mm.

EXPLANATION OF PLATE XX.

Fig. 1. *Trophon huttonii*, n. sp.; × 2.
Fig. 2. *Pleurotoma albula*, Hutton, var. *subalbula*, n. var.; × 3.
Fig. 3. *Lacuna (?) exilis*, n. sp.; × 10.
Fig. 4. *Odostomia (Pyramis) obsoleta*, n. sp.; × 10.
Fig. 5. *Actæon minutissima*, n. sp.; × 10
Fig. 6. *Ringicula uniplicata*, Hutton; × 22.
Fig. 7. *Clathurella sinclairii*, Smith.
Fig. 8. *Clathurella corrugata*, n. sp.
Fig. 9. *Pleurotoma gemmea*, n. sp.
Fig. 10. *Mactra scalpellum*, Deshayes.

The latter four figures were drawn with the aid of a camera lucida.

Art. XXVI.—*On the Nelson Boulder Bank.*

By W. F. Worley.

[*Read before the Nelson Philosophical Society, 13th November, 1899.*]

Plate XXI.

About six years ago I had the honour of reading before this Society a paper on the geology of this district. In the discussion which followed the reading of that paper I was asked for an expression of opinion upon the formation of the Boulder Bank. In reply to that question I stated that in all probability the Boulder Bank had been formed by the upheaval of a boulder stratum. Mr. Leslie Reynolds has evidently heard of this theory, for in his report on the proposed harbour improvements he says he can see nothing to support the theory that a reef underlies the bank.

One's own experience of the difficulties of understanding

the geology of a strange district enables one to excuse Mr. Reynolds for not being able to see the facts which support that theory; but when he hastily arrives at conclusions about this wonderful formation, and then bases estimates thereon involving the expenditure of thousands of pounds, I cannot help thinking that a little more caution would have been advisable. An eminent geologist from Australia told me he would require at least three months' residence here before he could express any opinion upon the geology of this district.

The origin of the Boulder Bank is a geological question, and most geologists when dealing with the subject have spoken more or less cautiously, realising the difficulties of the problem. The drift theory from Mackay's Bluff might be the true solution, but there is a good deal of evidence in favour of the other theory, that the Boulder Bank is the upturned edge of a stratum of rock or boulder drift.

I shall now proceed to give the facts upon which this theory is based, and then mention the difficulties which make it almost impossible to accept the opposite theory. In the hill above the Rocks Road may be seen a series of stratified rocks, inclined at very high angles. These rocks incline outwards from the face of the cliff, or, in geological language, they dip easterly. On the beach below the Rocks Road are also rocks standing almost on edge. In some places they have been planed down almost to a dead level by the action of the sea, and are covered by every tide; but in other parts, where the rocks are harder or less exposed, they are standing up in wall-like ridges above the general level of the beach. These rocks underlie, and are therefore older than those seen in the cliff. This series of rocks may be traced seawards till the Arrow Rock is reached, upon which they evidently lie at a very high angle. Now, it is strikingly apparent that the rocks in the cliff, and also those on the beach, must at one time have extended seawards in the form of an arch, forming a rounded hill. The Arrow Rock must therefore be regarded as the core of this hill, and this hill was not a mere cone, but had extension northwards and southwards. The strike of the inclined rocks on the beach and in the cliff is north-north-east and south-south-west, and it is also a remarkable fact that the Boulder Bank lies in a similar line. Keeping in mind the fact that a hill once covered the Arrow Rock, that this hill had a northward extension, as is shown by the parallelism of the stratified rocks in that locality, it follows naturally enough that a ridge of hills once occupied the present site of the Boulder Bank. The core of this ridge is represented by the Arrow Rock, which so far has resisted the denuding action of the sea. This, of course, is deduction, but it is deduction based upon solid facts which cannot be gain-

said. This ridge of hill, being composed of soft sandstones and clays similar to the rocks in the cliff and on the beach, has, with the exception of what remains at the cliffs, been washed away. The hard core of this ridge, composed of rock similar to the Arrow Rock remains, however, as an upstanding reef, forming the basis of the Boulder Bank.

Having shown that the existence of a reef under the Boulder Bank is highly probable, the next point for consideration is the nature of the rock of which this reef is composed. That the reef is similar to the Arrow Rock has already been remarked, but the Arrow Rock is only a fragment of an extensive belt of rock, and probably does not adequately represent the whole. An inspection of the Arrow Rock shows that it is made up partly of solid syenite rock and partly of syenite boulders firmly cemented together into a conglomerate. There is also in the syenite an intrusive sheet of lava. The boulders referred to form a part of the Arrow Rock, but lying around its base there are numbers of loose boulders which at one time doubtless formed part of the solid mass. These boulders are syenite, and quite similar to some of those found on the bank.

When the Torpedo Corps were improving the entrance to the harbour they blasted away rock made up of syenite boulders, and owing to its stubborn resistance found they could make but very little impression upon it with their charges of gun-cotton. Such, then, is the kind of reef that probably underlies the Boulder Bank—a boulder stratum, underlain by solid syenite, turned up on its edge by the upheaving force that raised the Port Hills.

There is no need to go into the origin of this boulder stratum beyond stating that it is probably the result of glacial action. In the cliffs above the Rocks Road several boulders of syenite have been unearthed. These stones prove conclusively that boulders were being carried in that direction while the rocks in which they are imbedded were being laid down as horizontal strata.

Given such a reef as has been described, then the origin of the Boulder Bank and the formation of Nelson Haven become simple matters, unbeset by any difficulties, and easily understood.

This theory of the Boulder Bank does not preclude the possibility of drift having come from Mackay's Bluff. In all probability—one might almost say certainly—boulders and shingle have drifted from there along the bank. This theory of the underlying reef, however, gives to the Boulder Bank its alignment, and removes some of the difficulties which make it hard to accept the purely drift theory. Some of these difficulties will now be mentioned.

It is a geological certainty that on the bottom of the greater part of the inner harbour—perhaps the whole of it—there are rocks standing practically on end. How far this arrangement of rocks passes beyond the Boulder Bank it is difficult to say, but that they do pass beyond must also be considered a certainty. Now, if the purely drift theory is to be accepted, we must suppose that these rocks were planed down by the action of the sea for at least 20 ft. below low water before any boulders were deposited. This, of course, is not an impossible thing to happen. Geological sections often reveal such an arrangement of rocks on their edges covered by horizontal strata. But in this case there is a difficulty. If these rocks were planed down, say, 20 ft. below the level of the sea, why were the Arrow Rock and the reefs near it not also planed down to the same depth? How would this denuding action reach from Mackay's Bluff to the Arrow Rock and then stop short? The thing is well-nigh impossible; when the sea planes it usually planes pretty smoothly. Then, supposing the planing-down process to the depth indicated did actually take place, what became of the boulders that were being formed at Mackay's Bluff at the same time? Did they stay there till the adjacent rocks had been planed down 20 ft. below sea-level and then start drifting south-west? Not a likely thing to happen. Another difficulty against the acceptance of this theory is the largeness of some of the stones at the extreme south of the bank. The advocates of the drift theory realise the difficulty, and suggest that heavier seas must at one time have prevailed in the bay. Now, how could those heavier seas have been produced—seas mighty enough to roll huge boulders ten miles along a level sea-bottom at a depth of 20 ft. from the surface? Only by so altering the coast-line that Tasman Bay would be more exposed to the ocean than it is at present. To effect this change of coast-line in the direction indicated we should have to give up some of our fundamental ideas of New Zealand geology. It would involve first the submergence and then the reappearance, in comparatively recent geological time, of some of the land by which the bay is at present sheltered. Then, too, the absence of gradation in the size of the stones on the bank, when viewed lengthwise, is another difficulty against the acceptance of the drift theory. It is a fact that some of the stones at the south end of the bank are as large as any to be found at the north end of the bank. If all these stones had been drifted from one place, one would expect to find large stones near the source, and a gradual diminution in size down to gravel or even sand as the distance from the source was increased. But such is not the case on the Boulder Bank.

The remarkable position of the bank, standing as it does some distance away from the shore-line of the inner harbour, is another difficulty. Why were the boulders not driven right in shore by those mighty seas, and piled up along the beach? It is all very well to speak about the opposing forces of the tides in the harbour; but where was that force when the bank was only a mile or two long? It did not then exist.

The last difficulty that I shall mention is the finding of stones on the Boulder Bank that are not to be found at Mackay's Bluff. On that part of the Boulder Bank lying south of the lighthouse there are numerous boulders of red syenite. This red syenite is not to be found at Mackay's Bluff. It, however, forms a part of the Arrow Rock, and the cause of its redness is there also apparent. When speaking of the composition of the Arrow Rock reference was made to an intrusive sheet of lava that had invaded the syenite. This lava contains much iron, and the syenite in contact with it has been stained red by the oxide of iron produced by decomposition of the lava. There are also on this part of the bank boulders of a very fine-grained rock which does not appear at Mackay's Bluff, but is found on the Arrow Rock. Having carefully examined the beach at Mackay's Bluff, the southern end of the Boulder Bank, and the Arrow Rock, I am fully convinced that the points of similarity between the rocks on the Boulder Bank and those of the Arrow Rock are far more striking than the same rocks compared with those of Mackay's Bluff.

Enough has now been said to show that the origin of the Boulder Bank is a question not easily settled simply by observation and reasoning. The sinking of a shaft on the bank, however, would probably set the matter at rest. Before attempting to cut the bank this preliminary precaution should certainly be taken. Although a strong supporter of the underlying-reef theory, it would be gratifying to me to find that the reef did not exist, because the facilities for improving our harbour would be then greater than I now consider them. If, on the other hand, a solid wall of syenite, or of firmly cemented syenite boulders, does underlie the bank, it would be well to know the truth before spending large sums of money on a work that might never be completed.

What has been said about the probable reef-formation of the Boulder Bank applies with equal force to the submerged banks within the harbour. As they too would have to be cut in carrying out the proposed harbour improvements, it would be necessary to test them also by boring to the required depth.

IV.—CHEMISTRY.

Art. XXVII.—*The Composition of the Soil of the Taupo Plains, and its Suitability for the Growth of Grasses.*

By J. A. Pond, F.C.S., and J. S. Maclaurin, D.Sc., F.C.S.

[*Read before the Auckland Institute, 6th November, 1899.*]

The immense area of comparatively level land lying to the north and east of Lake Taupo, and including the Kaingaroa and Patatere Plains, is the subject of our paper, and we shall refer to it collectively as the Taupo Plains. This country is frequently and correctly referred to by writers as the pumice plains of Taupo, which truly designates the class of material most frequently met with in travelling through any portion of it. The area of these plains may be roughly estimated at over 1,000,000 acres, of which a large portion is in possession of the Government, the remainder being in private ownership, or owned by the Maoris.

Viewed from the extinct volcanic mountain of Tauhara, at the north end of Lake Taupo the plain appears to be almost level, stretching for miles in an easterly direction, whilst to the north-east it assumes a more hilly appearance, interspersed with terraces which in places have been intersected by streams flowing transversely through them.

The Kaingaroa Plain, the portion of this large district to which we shall now give our closest attention, has an area of about 200,000 acres, of which about half is owned by the colony. This plain lies between the Waikato and its tributary the Waiotapu and the Rangitaiki Rivers, and has an altitude of from 1,200 ft. to 2,000 ft. above sea-level. The surface configuration is generally low-formed terraces and depressions, with occasionally small swamps or soakages, broken in places with deep gullies, the results of denudation. During the hot summer months the ground becomes dry, and the soil being but sparsely covered is speedily affected by strong winds, which give rise to miniature sand-storms, materially adding to the discomfort of travellers, and increasing the baneful effects of drought in uncovering the roots of

plants, and rendering them still more subject to the effects of the severe heat. During winter the temperature falls rapidly at times, and sharp frosts are felt, which, with the severe wind-storms that sweep across the plain, has a serious effect upon vegetation, and is a factor to be borne in mind in viewing the possibility of grassing this plain. Unfortunately there are no meteorological results obtainable nearer than Taupo or Rotorua, where the conditions are so different as to make them of but little value for the subject now under consideration.

The vegetation on the plain is chiefly stunted tea-tree, both *Leptospermum scoparium* and *L. ericoides*, and *Dracophyllum subulatum*, and a few other plants and mosses. The tussock-grass (*Poa australis*) is widely met with, and in some of the moister depressions—and particularly during spring and early summer—the young growth and flower-stalks attract large herds of wild horses, whose condition betokens fair nutriment even on these despised plains. Occasionally alongside the tracks, which ramify in a most bewildering manner, will be found patches of imported grasses and clovers growing luxuriantly, whilst on the edges of many of the swampy portions of the plain patches of white-clover often more than half an acre in extent may be found, cropped close and tramped to a beautiful lawn-like level, appearing as oases in the wilderness of pumice-sand and stunted tea-tree.

Now, it is impossible to traverse this vast plain, with its almost interminable monotony of pumice-sand and stunted vegetation, without wishing that it had been a rich basic instead of a poor acidic soil, without wondering whether it is not capable of some treatment which would at least make it of more value for grazing purposes than as at present, by the herds of horses that roam at large or the hares which have made their homes on the plain and appear to be on the increase. It was in this mood that we decided to investigate the subject. We were aware that some attention had already been given to the growth of various grasses by Mr. F. D. Rich, of the Patatere Plains, and, on behalf of the Government, by Mr. H. J. Matthews, at Rangitaiki, on the Kaingaroa Plain, to which we shall refer later; but no systematic analyses have been made of the soils, nor have the causes of the sparsity of vegetation been considered from the point of available nutrition in the land itself. Having, then, decided to investigate the matter, it was agreed that one of us should take the samples personally so far as possible, and in March and April last Mr. Pond commenced the work of obtaining them when on a visit to Taupo and the surrounding district. These samples were taken as far as possible uncontaminated by the ordure of animals, and under conditions which would best

secure a fair average of the class of soil composing the plain.

The first two samples were taken near Lake Taupo, on the eastern side. The surface here rises in terraces from the lake, and is irregularly and sparsely covered with stunted tea-tree and *Dracophyllum*, there being also a considerable amount of moss on the surface of the ground. The latter was removed, and the sample taken carefully to a depth of 9 in. At some distance further along the road a cutting had been carried through a pumice deposit, leaving the sides nearly vertical, about 7 ft. in height. The second sample was taken here, nearly at the bottom of the exposed cutting. By removing the outer layer a clean sample was obtained at 6 ft. from the surface. This deposit was white and moderately fine, and, being free altogether from organic matter, was chosen chiefly with a view to obtain a knowledge of the constituents unaffected by vegetation.

The third sample was taken near the Arateatea Rapids, about eight miles from Taupo. The soil here appears slightly better in character, and a considerable number of cattle were grazing in the vicinity. Although tea-tree is growing sparingly, yet between it in places there are various grasses and clover growing well, although cropped closely by the cattle. This sample was taken in a place as far removed as possible from other than indigenous vegetation; and, the surface-soil being removed, the earth was obtained as before to the depth of 9 in.

The fourth sample was taken from near the main road, three miles south of the Waiotapu Hotel. At this point, and in the vicinity of some swampy ground, a large patch of white-clover had been located, the vegetation being very closely cropped and the ground consolidated by the continued tramping. Choosing a place in this patch where the clover was not immediately apparent, the surface-soil to the depth of nearly 1 in. was removed, and the sample taken thence to a depth of 9 in.

For the fifth sample we are indebted to Mr. Brownlie, the resident foreman of the Taupo Road. At our request he obtained and forwarded a portion of soil from close to the Government experimental station at Rangitaiki. Our object was to secure a sample in the vicinity which had not been subjected to treatment, yet near enough to obtain a knowledge of the soil in which these grass experiments are being carried out.

Having thus obtained five samples which are fairly representative of a large portion of these plains, we decided to complete the tests of the acidic soils by an analysis, under the same conditions, of a sample of pumice, and this was taken

from a large nodule found in the hot baths at Wairakei. As the results of analyses of the samples thus obtained would be altogether on the soils formed from the acidic rocks, we felt that a comparison was needed of soils resulting from basic rocks, examined under the same conditions, and, as we had taken pure pumice to compare with the soils arising from degradation of this substance, we felt it incumbent to examine samples of pure basalt under like conditions. We therefore obtained from Mount Eden at different points two samples of volcanic soil and the rocks in the vicinity, choosing the soils from amid the rocks and boulders, which would preclude the likelihood that animals had grazed in their neighbourhood.

Having decided upon these two series of soils from the acidic and basic rocks for comparison, we felt that further benefit would be achieved by carrying out a similar examination of soil under cultivation in the Waikato district, and for this we are indebted to Mr. Chapman Ewen, of Cambridge, who has carefully obtained from his farm a sample to the depth of 9 in., taking this from a portion which had not been manured.

Now, the mere quantitative analysis of a sample of soil, giving its exact equivalent values of the various elements present, however carefully done, is almost useless to the cultivator, while the amount soluble in strong hydrochloric acid in a given time is almost as valueless. Until within the last few years this is all that could be determined, as the conditions of plant-life were not well enough known to permit of any other scheme being adopted. But science has stepped forward to the aid of the tiller of the land, and, in the hands of such men as Voelcker, Liebig, Way, Vogel, Tollens, Stutzer, and Dyer, a system has been carefully planned which has brought order out of chaos.

In a paper read before the Chemical Society by Dr. Bernard Dyer, reported in the March number of 1894, this gentleman shows by many results that the solubility of the mineral portions of the soil, in plants, is due to the acidity of the sap of their roots. He estimated the acidity present in the roots of about a hundred plants composed of different natural orders, and found that although there is a marked difference between various plants of different orders, and even in the same order, still an average could be obtained over the whole estimated as equal to a 1-per-cent. solution of citric acid. Dr. Dyer chose citric as being an organic acid, and therefore kindred to the acidity of plants. Following the reasoning of this writer, others have used aspartic, but, seeing the accuracy and value of the work done by citric acid, we decided to adhere to this solvent.

The conclusions arrived at by Dr. Dyer were that air-dried soils ingested in a 1-per-cent. solution of citric acid for seven days would yield to solubility all the material available for plant-food, and no more, thus leaving still undissolved a considerable amount not immediately available to the roots of plants, and which might be termed "latent." This we removed by treatment with hydrochloric acid, still leaving, after this acid treatment, elements of nutrition so locked up as to be of no avail for plant-life. The analysis of this material was then arrived at by fusion, thus giving a knowledge of the total constituents of the soil in three forms, as follows: (1) Non-available mineral material of plant-nutrition; (2) latent mineral material of plant-nutrition; (3) available mineral material of plant-nutrition.

The method of the chemical analysis has already been detailed, but we felt that this would be incomplete without a mechanical analysis, which has been arrived at by sifting through various grades as shown in Table IX., using meshes of twenty, thirty, sixty, and ninety holes to the linear inch, thus making five gradations by mesh, whilst a further division was made of the portion passing the 90-mesh by elutriation, this being performed in a conical glass vessel 8 in. in depth, with a constant stream of water 17 in. in height issuing through a hole $\frac{1}{10}$ in. in diameter, 1 in. from the bottom of the elutriator. As all the samples were treated under similar conditions the results are comparable. From all the samples stones were rejected which would not pass through a $\frac{1}{2}$ in. mesh, but there were very few in any of them. The results of this mechanical analysis will be found in Table IX. In this table we find that the combustible material is much lower in the Taupo soils than the Mount Eden, while the Waikato soil is between the two in this constituent.

The capillarity of all the soils was tested in tubes of 1·5 cm. diameter, standing in water. In some of these tubes the soil was shaken in loosely, and in others hard pressed. In all the capillarity was excellent, but the rise was greater in a given time in the hard-pressed samples than those loosely shaken.

The results of our analyses are shown in the following tables, and are arranged as follows: Nos. 1 to 6 (inclusive), from Taupo; Nos. 7 to 10 (inclusive), from Mount Eden; No. 11, from Waikato; and Nos. 12 and 13, from Rothamsted barley soils. The last two are taken from Dr. Bernard Dyer's paper, to which we have already referred, and they represent constituents found in contiguous plots of ground which had been under barley-crops for thirty-eight years. During that period No. 12 plot had received no manure of any kind, whilst No. 13*a* had received annually $3\frac{1}{2}$ cwt. of super-

phosphate, and No. 13*b* had received 200 lb. sulphate of potash, 100 lb. sulphate of soda, and 100 lb. sulphate of magnesia.

We have already referred to the three classes into which the constituents of a soil may be divided, namely: (1) Non-available mineral material for plant-nutrition; (2) latent mineral material for plant-nutrition; (3) available mineral material for plant-nutrition. These divisions are shown in the following tables, the first class being represented in Tables I. and II.—that is, those constituents insoluble in boiling hydrochloric acid; the second class in Tables III. and IV.—*i.e.*, those constituents soluble in hydrochloric acid excluding the amount soluble in citric acid; and the third class in Tables V. and VI.—*i.e.*, those constituents soluble in citric acid. Whilst the results in the first and second class are of considerable interest, as showing the composition of the soils and the stores of latent plant-food contained in them, we may pass at once to the consideration of Class III., since in this we have a measure of the present fertility of the soils.

For the sake of clearness we repeat the most important results in Tables VII. and VIII. Before considering these results let us determine by what standard of fertility we shall judge them. Dr. Dyer's investigations led him to consider that a soil containing as little as 0·005 per cent. of available potash is not in immediate need of potash manures, whilst one containing more than 0·01 per cent. of available phosphoric acid does not require special phosphatic manuring. If we adopt these standards it is at once evident that the Taupo soils are, on the whole, in a fertile condition. In potash they are all above Dr. Dyer's limit, and, with the exception of Nos. 4 and 6, very much above that limit. In phosphoric acid the first three soils are from two to four times the limit, and are higher than the Mount Eden basic soils, which are noted for their fertility. Of the remaining three Taupo soils No. 5 is very little under the limit, No. 6 is about half that quantity, and No. 4 is very poor. It will be remembered that No. 6 is pure pumice, and not a sample of the Taupo soil, and as such may be left out of consideration. That being so, No. 4 is the only sample that is decidedly deficient in phosphoric acid. It is evident from the foregoing that all the requirements other than nitrogen are well represented, but if we refer to Table VIII. we shall see that, without exception, the results under the Taupo soils are very low, and there is not the slightest doubt that they are altogether too low to give luxuriant plant-growth.

TABLE I.—INSOLUBLE IN HYDROCHLORIC ACID. (Percentage Composition.)

—	Taupo.						Mount Eden.				Waikato	Rothamsted.	
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12	13.
Silica	64·41	68·74	63·18	73·94	61 43	71·90	43 32	32 16	46·96	33 58	51·16	...	...
Alumina	14·22	14·94	13·82	10·22	12·60	13·40	9 40	5 78	9 60	4·71	10 40	.	...
Oxide of iron	2·48	2 32	1·82	0·77	2 73	2 16	3 72	1·67	3 12	0·84	1·60	..	...
Lime	2·50	2·16	2·30	0·94	2 64	1 68	7 76	2·28	7·84	1·02	1 78	...	...
Magnesia	0 60	0·37	0·55	0·12	1·12	0·27	3 00	1·00	2·88	0.51	0·68	...	...
Soda	3·22	3·78	3·18	1·57	2·58	3 21	1 26	0·78	1·39	0 73	1 78	...	..
Potash	1·61	2·17	1·80	1·37	1·50	2 17	0·53	0·39	0·35	0 42	1·12	1·255	1·377*b*
Phosphoric acid	...	...	...	...	...	0·03	..	...	0·034	.	.	..	...
Organic matter and water* ...	6·60	2·90	7·70	6·90	11·40	3 70	1 60	32 78	1·50	26 74	19 97	..	...
Total	95·64	97·38	94·35	95 83	96·00	98 52	70 59	76 84	73 67	68·55	88·49	...	..

TABLE IA.

Nitrogen	0·110	0·017	0·1736	0·1316	0·2436	...	..	0 848	...	0 686	0 384	...	...

TABLE II.—INSOLUBLE IN HYDROCHLORIC ACID. (Pounds per Acre.)

—	Taupo.						Mount Eden.				Waikato	Rothamsted.	
	1.	2.	3.	4.	5.	6.	7.	.	9	10.	11.	12	13.
Silica	1,278,400	1,442,620	1,200,150	1,446,520	1,031,310	1,438,000	866,400	581,100	939,120	637,880	1,037,320	...	...
Alumina	282,250	313,547	262,579	200,000	211,500	268,000	188,000	104,250	192,000	89,455	210,870	...	..
Oxide of iron	49,226	46,720	34,580	15,065	45,837	43,200	74,400	30,179	62,400	15,960	32,442	...	...
Lime	49,718	45,360	43,700	18,391	44,326	33,600	155,200	41,202	156,800	19,380	36,091	...	..
Magnesia	11,910	7,770	10,450	2,348	18,806	5,400	60,000	18,071	57,600	9,690	13,788	..	...
Soda	63,914	79,380	60,420	30,710	43,486	64,200	25,200	14,095	27,800	13,870	36,091	...	...
Potash...	31,957	45,570	34,200	26,804	25,185	43,400	10,600	7,547	7,000	7,980	22,700	31,978	34,809*b*
Phosphoric acid ..	...	...	. .	...	...	600	...	...	680	...	...	..	...
Organic matter and water* ...	130,983	60,865	146,270	134,998	191,406	74,000	32,0	592,196	30,000	507,960	404,920	...	...
Total	1,898,358	2,043,832	1,792,349	1,874,836	1,611,856	1,970,400	1,411,800	1,388,640	1,473,400	1,302,175	1,794,222	...	...

TABLE IIA.

Nitrogen	2,183	357	3,298	2,575	4,090	...	...	15,324	...	13,034	7,786	...	...

TABLE III.—SOLUBLE IN HYDROCHLORIC ACID BUT INSOLUBLE IN CITRIC ACID. (Percentage Composition.)

—	Taupo.						Mount Eden.				Waikato	Rothamsted.	
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Silica	0·040	0·114	..	0·186	..	0·230	1·902	0·051	..	Not	determi	ned.	..
Alumina ..	0·822	0·397	1·902	1·910	1·185	0 258	7·278	8 766	9·084	15·662	5·860	..	..
Oxide of iron ..	1·667	1·131	1·383	0·800	1·115	0·235	9·655	10·584	9·040	12 080	3·316	..	..
Lime	0·267	0·220	0·271	0·224	0·273	0·088	1·844	0·274	1·904	0 190	0·114	..	..
Magnesia ..	0·130	0·108	0·214	0·127	0·075	0·133	4·150	0·415	2·818	0·877	0 054	..	..
Soda	0·0868	0·1108	0·0835	0·0779	0·1102	0·1508	0·5013	0·0590	0·391	0 076	0 032	..	..
Potash	0·0787	0 0722	0·0430	0·0932	0·0787	0 0790	0·2245	0 0925	0·124	0·079	0·0568	0 1794	0·2814*b*
Phosphoric acid ..	0·0320	0·0080	0·0210	0 0625	0·0443	0·0046	0·1192	0 3060	0·093	0 686	0 2195	0 0945	0 1357*a*
Sulphuric acid ..	0·0370	0·0243	0·0537	0·1854	0·0240	0·0127	0·0113	0·1739	0 015	0·157	0 100	..	..
Total ..	3·1605	2·1853	..	3·6660	..	1·1911	25·6853	20 7214	..	..	..	..	..

—	Taupo.						Mount Eden.				Waikato.	Rothamsted.	
	1.	2.	3.	4.	5.	6	7.	8.	9.	10.	11.	12.	13.
Silica	791	2,392	..	3,639	..	2,600	38,040	920	..	..	..	..	..
Alumina ..	16,309	8,333	36,129	37,372	19,900	5,160	145,560	158,404	181,680	297,523	118,817	..	..
Oxide of iron ..	33,071	23,741	27,267	15,652	18,718	4,700	193,100	191,244	180,800	229,461	67,236	..	..
Lime	5,306	4,618	5,149	4,382	4,584	1,760	36,880	4,949	38,080	3,610	2,311	..	..
Magnesia ..	2,581	2,264	4,065	2,484	1,259	2,660	83,000	7,499	56,360	16,657	1,096	..	..
Soda	1,724	2,323	1,586	1,524	1,850	3,016	10,026	1,067	7,820	1,444	649	..	..
Potash	1,562	1,517	817	1,823	1,321	1,580	4,490	1,672	2,480	1,501	1,152	4,535	7,114*b*
Phosphoric acid ..	635	168	399	1,222	744	92	2,384	5,530	1,860	13,034	4,451	2,364	3,431*a*
Sulphuric acid ..	734	510	1,026	3,627	403	254	226	3,143	300	2,983	2,023	..	..
Total ..	62,713	45,866	..	71,725	..	23,822	513,706	374,428	..	..	..	..	..

TABLE V.—SOLUBLE IN CITRIC ACID. (Percentage Composition.)

	Taupo.						Mount Eden.				Waikato.	Rothamsted.	
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Silica	0·116	0·102	0·320	0·160	0·230	0·070	0·848	0·260	0·844	0·402	0 362	..	..
Alumina	0·688	0·116	0·948	0·100	0·810	0 042	0 552	1 714	0·866	1·338	1 460	..	..
Oxide of iron	0·260	0·084	0·312	0·140	0·066	0·140	1·920	0 176	1·760	0·150	0·154	..	..
Lime	0·066	0·050	0·074	0·070	0 042	0 012	0 056	0·212	0·066	0 080	0·086	..	..
Magnesia	0·010	0·016	0·015	0·017	0·009	0·002	0·270	0·036	0·092	0 033	0·016	..	..
Soda	0·0132	0·0232	0·0135	0·0091	0 0098	0·0062	0·0307	0 0160	0·029	0 014	0·008	..	..
Potash	0·0113	0·0178	0·0200	0·0068	0·0113	0·0070	0 0145	0 0075	0·016	0·011	0·0132	0·0036	0·0366*b*
Phosphoric acid ..	0·0280	0·0200	0·0440	0 0025	0 0087	0·0054	0 0208	0·0140	0·027	0 014	0·0205	0·0055	0 0463*a*
Sulphuric acid ..	0·0080	0 0047	0·0053	0·0026	0 0040	0 0033	0 0107	0·0011	0 005	0·003	..	..	..
Total	1·2005	0·4337	1·7518	0·5080	1·1908	0·2879	3·7227	2·4366	3·705	2·045	2·1197	..	..

TABLE VI.—SOLUBLE IN CITRIC ACID. (Pounds per Acre.)

	Taupo.						Mount Eden.				Waikato.	Rothamsted.	
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11	12.	13.
Silica	2,303	2,141	6,079	3,130	3,862	1,400	16,960	4,698	16,880	7,635	7,340	..	..
Alumina	13,656	2,434	18,010	1,956	13,600	840	11,040	30,974	17,320	25,412	29,603	..	..
Oxide of iron ..	5,161	1,763	5,929	2,739	1,108	2,800	38,400	3,181	35,200	2,849	3,122	..	..
Lime	1,310	1,049	1,406	1,370	705	240	1,120	3,831	1,320	1,520	1,744	..	..
Magnesia	198	336	285	333	151	40	5,400	651	1,840	633	324	..	..
Soda	262	487	257	178	165	124	614	289	580	266	162	..	..
Potash	224	373	380	133	190	140	290	135	320	209	268	91	925*b*
Phosphoric acid ..	556	420	836	49	146	108	416	253	540	266	415	139	1,170*a*
Sulphuric acid ..	159	99	95	51	67	66	214	20	100	57	..	..	..
Total	23,829	9,102	33,277	9,939	19,994	5,758	74,454	44,032	74,100	38,847	42,978	..	..

TABLE VII.—SOLUBLE IN CITRIC ACID. (Percentage Composition.)

—	Taupo. 1.	2.	3.	4.	5.	6.	Mount Eden 7.	8.	9.	10.	Waikato 11.	Rothamsted. 12.	13.
Potash	0·0113	0·0178	0·0200	0·0068	0 0113	0·0070	0·0145	0·0075	0 016	0 011	0 0132	0·0036	0·0366*b*
Phosphoric acid ..	0·0280	0·0200	0·0440	0·0025	0·0087	0 0054	0 0208	0 0140	0·027	0 014	0·0205	0·0055	0 0463*a*

TABLE VIII. (Percentage Composition.)

—	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.*	13.
Nitrogen	0·110	0·017	0·1736	0·1316	0·2436	..	..	0·848	..	0 686	0·384	*	*

TABLE IX.—MECHANICAL ANALYSIS.

—	Taupo. 1. Fixed Sub-stances.	1. Com-bustible Matter.	2.† Fixed Sub-stances.	3. Fixed Sub-stances.	3. Com-bustible Matter.	4. Fixed Sub-stances.	4. Com-bustible Matter.	5. Fixed Sub-stances.	5. Com-bustible Matter.	Mount Eden. 8. Fixed Sub-stances.	8. Com-bustible Matter.	10. Fixed Sub-stances.	10. Com-bustible Matter.	Waikato. 11. Fixed Sub-stances.	11. Com-bustible Matter.
Rejected by 20-mesh (gravel) ..	27 00	1·10	32·90	30·20	1·10	4·10	0·10	10·75	0·60	4·75	1·30	Nil	Nil	7 45	0·10
„ 30-mesh (coarse sand)	8·95	0·35	10 25	10·70	0·35	3 50	0 20	5·95	0·70	1·55	0·70	0·18	0 60	5·65	0 05
„ 60-mesh (sand) ..	12·35	0 35	11·10	12·10	0·50	4·35	0·15	10·65	1·10	6·65	2 60	15 00	4·62	8·38	0·43
„ 90-mesh (fine sand)	5·80	0·15	5·05	8·40	0·80	5·85	0·20	8·60	0·55	3·70	1·40	9·99	2·88	5 70	0 05
Through 90-mesh (very fine sand)	13·50	0 80	15·52	13·77	0 67	16 82	2·04	27·77	1·90	12·62	4 62	21·72	6·10	25 84	2·38
„ elutriator (fine soil) ..	20·30	6 00	23·28	15·70	1·78	55·94	2·19	26·13	1·70	50·60	5·00	26·64	8·74	34·17	7·95
	8·75	8·75		5·20	5·20	4·88	4·88	6·55	6 55	15·62	15·62	22·94	22·94	10 96	10·96
	96·65		98·10	96·07		95·44		96·40		95·49		96·47		98·15	

* Not determined. † No combustible matter present.

We have now shown that the soil from these plains has the needed mineral constituents to produce grass in abundance, and that these are in ample supply, both in available and latent form, for a considerable time.

The mechanical conditions of the soil are also more satisfactory than we had anticipated, particularly as regards its capillarity. We have therefore much in favour of a successful trial of grassing the plains. The serious difficulty we have to contend with is the almost entire absence of nitrogen, without which no extensive amount of feed can be developed by the grasses. The great difficulty of carrying manure to the district, besides the cost, makes it necessary to rely considerably upon the growth of leguminous plants, either in the form of lupins, to be turned under prior to sowing the grass-seeds, or of clovers, peas, and beans for grazing; probably the combined methods would yield the best results.

As we have already remarked, white-clover grows luxuriantly in some of the depressions, as well as alongside the tracks crossing the plains. Now, the fact of this luxuriance points to the presence in the soil of the nitrifying bacteria, which enables the class of plants under review to provide nitrogen from the air or the nitrate-nitrogen supplied by the rain. A matter for consideration, however, is the inoculation of the soil in places with earth bearing these particular bacteria, or, perhaps better still, with pure cultivations of the bacteria applied at regular distances, the spread of which would speedily produce the object sought.

The choice of grasses best suited for these plains is one of the most difficult portions of the problem. That white-clover will grow under favourable conditions we have already shown, and we have evidence that some of the imported grasses will bear the conditions of life in this district, as evidenced by a report from Mr. Matthews in the Report of the Department of Lands and Survey dealing with the experimental station at Rangitaiki upon grasses sown more than twelve months previously, in which this gentleman remarks, "The following grasses have done fairly well on this reserve: Prairie-grass, Chewing's fescue, *Poa pratensis*, crested dogs-tail, white-clover, and tall fescue, the latter making by far the most headway"; and by the following letter from Mr. Brownlie, written in May last, dealing with the same reserve: "In regard to this paddock, I may state that several of the grasses are doing well, especially Chewing's fescue, hard fescue, prairie-grass, and white-clover, in the order named, the best of all being Chewing's fescue, which is looking well, and throws a lot of feed. This is satisfactory considering the very unsatisfactory conditions under which it was sown—I mean poor soil, cultivation, and drought." But although

the grasses named may be of much value, still there are objectionable features in the small volume of feed yielded by the fescues, and the doubt as to the prairie-grass bearing feeding off.

To our minds the cultivation of some of the New Zealand grasses opens up a subject of immense interest and importance. There are four which we would name of value for this problem—*Microlena stipoides, Danthonia semiannularis, Poa colensoi,* and *Poa kirkii.* The first of these—*Microlena*—is a native grass which has of late come into considerable repute owing to its spreading habit and apparent ability to withstand drought. On some of the east coast runs this grass has proved of great value on account of the amount of food produced in dry periods and the avidity with which sheep and cattle eat it. The second named, the *Danthonia semiannularis,* is also a native grass of much value, although it is questionable whether it will yield as much feed as the last named; it is, however, capable of adapting itself to considerable changes, and may prove of value. Both of these grasses grow at Okoroire in land of similar character to that at Taupo, and, we think, can be established in the plains if attention is given to the matter. We are indebted to Mr. Cheeseman for the suggestion of the *Poa colensoi* and *Poa kirkii.* These are subalpine plants growing in the South Island, and would well repay the experiment of cultivation under the conditions obtaining on the Kaingaroa Plains, and if once established there could be no doubt of their value for feeding purposes. This by no means exhausts the native grasses, but attention should be given to those growing on the higher lands at Otago, as these will be more nearly under the same conditions as Taupo.

Under favourable cultivation the alteration of the surface of the ground will be marked, as there will be a reduction of radiation of heat and moisture, whilst the wind-action on the soil will be considerably lessened. We have already suggested the growing of leguminous plants, and would advise the planting of furze in the more favourable situations. If this plant can be established it will provide both food and shelter. That there will be a difficulty in this we have no doubt; in fact, Mr. Brownlie's letter, referring to our conversation on the gorse, leans in this direction; but this plant will prove of such exceptional utility, especially in the mode of operations we propose to adopt, that even temporary breakwinds might have to be erected until the first rows of this plant were strong enough to resist wind-pressure.

We have shown that the soil, so far as its constituents are concerned, with the exception of nitrogen, is well able to supply the necessary food for plants in considerable quantities.

Contrary to our expectations, we found a large percentage of the finely powdered soil in all our samples, ranging from 15·7 in No. 3 to 55·94 in No. 4. We have found also, as this would lead us to believe, that the capillarity of the soil is excellent, provided that due consolidation is obtained. The absence of this, owing to the loose texture of the soil, has in our opinion very much to do with the sparsity of vegetation growing on the plains. If this is remedied and nitrogen furnished there should be no reason, other than a climatic one, why the plains should not produce a large quantity of valuable feed. The mere ploughing, harrowing, and sowing will certainly not attain this object; and, although rolling with heavy rollers will give a certain amount of compression, the absence of clay and humus will not allow of consolidation without frequent rolling. This will prove costly, and not yield nearly as satisfactory results as that secured by the tramping of sheep or cattle.

Now, the folding of sheep in small paddocks treated as we have advised would be by far the most effectual method, but the absence of more than the most meagre fare would entail a very heavy mortality at first. It is possible, however, to choose a more hardy animal in the goat, and by this means to achieve results which we think will prove successful in several ways. In the United States Year-book of the Department of Agriculture for 1898 is a very carefully written paper on the Angora goat, by A. Barnes, where it is shown that in almost every State, with the exception of Alaska, the Angora goat can be raised, and, in many given instances, with considerable profit. The greatest success has been attained with them where the altitude is about 500 ft. and the climate fairly dry. Their ability to live and thrive on herbage which other animals reject is shown, whilst the habit of travelling much further than sheep in feeding make the feasibility of herding them unquestioned. As the writer says, "There is the additional incidental benefit that whatever foul land is regularly pastured by these animals for a few years becomes clean, weedless, and bushless, and, usually being evenly fertilised by them also, runs into nutritious grasses."

The following statements from the same paper will give a better idea of the value this animal has proved under circumstances not much different from those we are considering:—

"The ease with which they can be kept, living as they do on weeds, briers, browse, and other coarse herbage, fits them for many portions of our country where sheep cannot be sustained to advantage, while their ability and disposition to defend themselves against dogs evidence a value peculiar to

the race. They are free from all diseases to which sheep are liable, hardy, and prolific, and experience has proven that they readily adapt themselves to all portions of the United States. The bucks breed readily with the common goat, the second cross yielding a fleece of practical utility, while the fourth is but little inferior to that of the pure breed. A flock of valuable wool-bearing goats can be raised in a few years by using grade bucks. The animals are hardy, good rangers, and long lived when compared with sheep, and do well on land where other animals find it hard to live. Their value as brushwood-cleaners can hardly be estimated; but Mr. Stanley, of Iowa, writes as follows: 'To a person who has never seen the results of the application of Angoras to brush land a ride through my blue-grass pastures is a revelation. Where three years ago the ground was densely covered with undergrowth of hazel, crab-tree, oak, buckberry, and other brush, it is now growing the finest bluegrass. At the present time I have over 600 acres which have been reclaimed, and a conservative estimate would be that the value of the land has thereby been enhanced at least $10 per acre.'"

The benefits arising from the systematic rearing of these animals will not be solely for the enrichment and consolidation of the land, for the hair and hides are of commercial value, which will materially reduce the cost of the work. Mr. Barnes quotes the number of goats in the United States at half a million, of which one-half are Angora, and yet into that country are imported annually goat-skins to the invoice value of over £3,000,000.

We would strongly urge that this experiment should be undertaken at an early date, and, as Mr. Barnes has shown that the fourth generation of a cross between the Angora and the ordinary goat will yield an animal almost equal to the first progenitor, it would be well to take ordinary does with pure-bred Angora rams, and, by herding them during the day and folding on one of several small paddocks at night, the minimum of cost and maximum of benefit would be obtained. Some paddocks should be prepared, the ground ploughed, harrowed, and rolled, and good seed of various grasses and clovers sown, or, if available, turfs of the *Microlena* and *Danthonia*. It would be well also in one or more of these paddocks to sow lupins as suggested, to be turned under before sowing the grasses. These paddocks would be utilised for the weaning and care of the kids, and subsequently for folding the older animals at night, they being herded in the day. The gradual clearing, consolidation, and grassing of the plains would thus start from a nucleus to be extended as it was found to succeed. The cultivation of the cow-pea in the

summer-time, to produce a rough hay for winter feeding, would add materially to the nitrogen reserve by giving available nitrogenous food, and thus further enriching the land with this most necessary constituent.

We have by no means exhausted the subject, for much remains to be done in the chemical and meteorological portions of the subject; but we have endeavoured to show how important the matter is, and that, in our opinion, it is capable of successful demonstration. How much further these experiments towards the production of a grazing country could extend we would hardly like to hazard a guess, but that much is capable of being done we are convinced. So earnestly do we feel in this matter that we are quite prepared to devote a large portion of our time and energy to bring this experiment to a successful issue if so desired. Money is often expended by our Government on schemes of far less value than the one we have in view; in this case, however, the cost to the colony would be very small, whilst the beneficial results accruing may be incalculable.

ART. XXVIII.—*On the Percentage of Chlorine in Lake Takapuna.*

By J. A. POND, F.C.S.

[*Read before the Auckland Institute, 25th September, 1899.*]

ON account of the proximity of Lake Takapuna to the sea, and its being considerably deeper than Rangitoto Channel, the question has been raised as to whether there may not be a substratum of sea-water in the lake at depths below the channel in question. To decide this matter I have made tests of the water taken from the lake at various depths.

Lake Takapuna, or Pupuki, is stated by Hochstetter to be a volcanic crater having a depth of 28 fathoms, or 168 ft. It has a superficial area of 268 acres, and its eastern edge is not more than 200 ft. from high tide in Rangitoto Channel, while the tidal waters of the Waitemata Harbour in Shoal Bay approach within 400 yards of its western edge.

The deepest part of Rangitoto Channel is given on the charts as 8 fathoms, or 48 ft., at low water: therefore the bottom of the lake is, according to Hochstetter's measurement, 100 ft. below the deepest part of the channel, estimating the surface of the lake at 10 ft. above high-tide mark, and the rise of tide at 10 ft.

From analyses we have made at various times the chlorine

at the surface is found to be fairly constant, and the same remark applies to the total solids. As an instance of this, three samples were taken on the 2nd December, 1897, the first being from about 100 yards from the edge and from 14 ft. below the surface of the lake, the second being from the pump-well at the pumping-station, and the third from the Council Chambers at Devonport. These samples yielded chlorine 2·87 gr. per gallon in each instance, while the total solids at 105° C. were 8·68 gr. per gallon from the lake and Devonport samples, the pump-well giving 8·96 gr. per gallon.

To obtain the water from the bottom of the lake I used the apparatus advised by Fresenius, the results being satisfactory. The first sample was taken at 50 ft. below the surface, the water being clear and without sediment. The second sample was taken at a depth of 100 ft., the water being also clear and free from precipitable matter. The third sample was taken from the bottom of the lake, at a depth of 157 ft., the water containing a small amount of sediment. These samples were taken from midway between the pumping-station and the wooded shore opposite, this being stated as the deepest part. A fourth sample was then obtained about 100 yards nearer the wooded shore, the depth being 160 ft. This sample was very turbid, and contained a considerable amount of ooze from the bottom, which precipitated completely after twenty-four hours. A fifth cast was made at a depth of 163 ft., no water being obtained on this occasion, this being made as a test of the apparatus, which was found to work satisfactorily.

The results of analysis gave chlorine 2·87 gr. per gallon, equal to chloride of sodium 4·73 gr. in each sample, while the total solids gave 8·68 gr. per gallon in each instance, the water from the bottom of the lake being decanted from the precipitated matter. There is therefore not the slightest difference in these two factors of the water's purity at varying depths, and these agree with our analyses of samples taken at various periods.

The deposit from the lake-bottom was composed chiefly of vegetable *débris* and ferruginous clay, together with a large number and variety of diatoms, some amongst them being very beautiful objects.

The fact that Lake Takapuna is a water-supply of great purity, and that its present utilisation must be very largely increased in the not distant future, is, I think, more than sufficient apology for my bringing this subject before you.

V.—MISCELLANEOUS.

Art. XXIX.—*The Animal Mind as a Factor in Organic Evolution.*

By Charles W. Purnell.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1899.*]

In the manifold discussions which have taken place upon the subject of evolution, and the consideration of the factors concerned in the development of the animal from a simple to a complex being, but little importance has been attributed to the action of the animal mind upon the development of the animal body. Those who accept Darwin's views of the operation of natural selection, and those who consider that natural selection plays a comparatively insignificant part in the development of the animal kingdom, alike seem to regard the animal as the unconscious sport of outward circumstances, and conclude that an animal such as the elephant has been evolved from a simpler type by surrounding conditions acting upon its physical structure, which has thus become moulded to suit its altered environment. The mind of the animal, even in the case of animals gifted with a high order of intelligence, is not assigned any part in the drama of evolution, with one exception—viz., that sexual desires have produced sexual decorations, and particularly the decorative plumage of birds, although this is not undisputed.

The foregoing is the view of evolution held by British naturalists, at all events; and I ascribe it to the fact that, when Darwin published his "Origin of Species," which really first awakened the world to the importance of the doctrine of evolution, it was not conceded, as it is now, that animals—at any rate, those of the higher orders—possess true minds, and the "instincts of animals" were regarded as something fundamentally different from human intelligence.

The only scientific writer of note who has claimed for animal intelligence any direct share in the moulding of the animal frame is the late Professor Cope, of the United States, who, in his work on "The Origin of the Fittest," writes,

"Intelligence is a conservative principle, and will always direct effort and use into lines which will be beneficial to its possessor. Here we have the source of the fittest—*i.e.*, addition of parts by increase and location of growth-force — directed by the influence of various kinds of compulsion in the lower and intelligent option among higher animals. Thus intelligent choice, taking advantage of the successive evolution of physical conditions, may be regarded as the originator of the fittest, while natural selection is the tribunal to which all results of accelerated growth are submitted. This preserves or destroys them, and determines the new points of departure on which accelerated growth shall build."

I think Professor Cope goes much too far in assuming that the intelligence of animals always directs effort and use into lines which are beneficial to its possessor; for, if such were the case, the intelligence of animals would surpass that of mankind. A little reflection will, however, show that the action of animal intelligence, even where the intelligence is of a limited order, must necessarily largely influence the development of the body, although such influence, instead of being conscious choice, must be exercised unknown to the animal itself. The animal uses its intelligence to supply its daily wants, and in doing so it is brought within the sphere of new physical surroundings, which modify its bodily structure. By way of illustration, let me point to the New Zealand kokako, or crow. Now, the blue-wattled crow is confined to the North Island, while the orange-wattled crow is restricted to the South. Ornithologists class these two crows as distinct species. No naturalist would contend that these two members of the crow family had been independently evolved in the North and the South Island—obviously one of them is a modification of the other. Impelled by lack of food or perhaps other circumstances, the intelligence of the ancestors of one of these crows led them to migrate from the North to the South Island, or *vice versâ*, and the change of climate and diet, with possibly other alterations in the environment, led to the production of a new species, or what we, for convenience sake, call a new species.

Individual animals, like human individuals, and races of animals, like races of mankind, display marked peculiarities of mental character; and in dealing with domesticated animals man has often taken advantage of these idiosyncracies, and, in so doing, has modified the physical structure of various animal breeds. Thus, breeds of hounds of fierce disposition and prone to the chase, breeds of spaniels of affectionate temper and ways, have been created; while the collie, quick and watchful, has been taught to tend flocks of sheep and

herds of cattle. The physical structure of each breed has become modified to suit its place in life, and to better adapt it to fulfil what its mental capacity enables it to perform.

The chief occupations of an aminal are to provide itself with the means of subsistence, sometimes with shelter, to defend itself against the attacks of enemies, and to multiply its kind. Those animals which are gifted with the most intelligence, whose appetencies and desires are the keenest, are the most likely to succeed in the struggle for existence. Not, indeed, always so. A fatal and wide-spreading disease like the rinderpest may doom millions to death; it may spare less intelligent animals, possessing bodily peculiarities fitting them to resist the disease, and carry off individuals more intelligent, but with constitutions prone to the disease; a great catastrophe of nature, like a flood or volcanic eruption, an extraordinary period of frost or of hot weather, may destroy vast numbers, and neither superior intelligence nor superior strength of body may avail to save the animal's life. Leaving out of account, however, such special causes of mortality, it is plain that the individual animal of any species which is gifted with an active intelligence will be more likely to hold its own than the individual whose mind is sluggish. The cat which discomposes the household by its thievish propensities would, in the wild state, manage to provide itself with an excellent living where the well-behaved tabby would starve. The bird of any species which best conceals its nest from the enemies which prey on its eggs and young, and most carefully nurtures its young, will be more likely to leave progeny surviving it than another bird of the same species whose less active intelligence make it less successful in the performance of these parental offices.

It is to the varying mental characteristics of animals that the dispersal of animal races and the multiplication of species is largely due. Professor Karl Semper has shown how certain species of crustaceans can be transmuted into one another according to the saltness of the water in which they live. He proved by experiment that a small crustacean named *Artemia milhausenii*, which lives in salt-water, can be transformed into an apparently entirely different crustacean called *Branchipus stagnalis*, which inhabits fresh water, the two animals being so different in outward aspect that naturalists had classed them as belonging to different genera. Now, in nature either *Artemia milhausenii* must have migrated from fresh water to salt, or *Branchipus stagnalis* from salt water to fresh, and in either case it must have been impelled by its own mental desires to seek the change of habitat which has produced so marked an effect upon its bodily structure. There

is nothing to lead us to suppose that this is an isolated instance. Indeed, many fresh-water fish are obviously modifications of marine forms. Heilprin writes, "Of so little importance does a change of medium appear to be in many cases that it is frequently very difficult, or impossible, to indicate whether a given group of fishes is more properly of a marine or fresh-water type. The numerous instances where certain species of a genus are of one habit and other species of the same genus of the opposite habit render the determination of this question still more difficult."

Some animals are of a more restless disposition than others. We find such to be the case amongst domesticated races. Some cows are habitual fence-breakers, and special means have to be adopted to keep them in enclosed fields; while other cows, so long as a field contains sufficient pasture for their wants, will remain contentedly in it. Even a dull-witted creature like the domesticated sheep exhibits similar idiosyncracies. I knew a farmer who owned a small flock of sheep which was so addicted to straying that the sheep actually learned to leap over gorse fences of considerable height. Wild animals doubtless exhibit similar traits of character; and when, impelled by a desire for change, a herd of animals moves on to a fresh region, the effect may be that it will permanently take up its abode in a new country, where its changed environment will cause it to ultimately develope into a new species. Even if it leaves its original habitat owing to lack of food or persecution by enemies, the intelligence of the animal nevertheless comes into play by leading it to migrate and choosing the direction. But for the exercise of intelligence the animal would fail to seek food in fresh regions or to retreat thither from its enemies; and it is easy to perceive that a particular herd of animals of quicker intelligence than another herd might escape dangers which would prove fatal to the latter. The extraordinarily large herds of antelopes which, until recently, roamed in South Africa could never have existed in a country so abounding in savage beasts of prey but for the exercise of ceaseless vigilance on the part of the members of those herds, and any particular herd which relaxed its vigilance must speedily have disappeared. The alertness of the antelope's disposition finds its outward expression in the physical structure of the animal; a vigilant mind is aided by the power of rapid flight, while the power of rapid flight would be of little use divorced from an active intelligence.

The circumstance that an animal of feeble frame is subject to the frequent attacks of a beast of prey serves to keep the intelligence of both up to the highest pitch; to make the assailant cautious and cunning, and the attacked vigilant and

active, the constant strain in each case tending to develope and strengthen those physical characteristics which best tend to the animal's preservation. There is thus an unceasing reciprocal action going on between the intelligence of animals which either associate together or are frequently brought into contact as enemies.

It is the intelligence of animals which has led them to associate together in communities, often very large, by means of which they afford mutual aid against enemies, and also enjoy social intercourse. The latter, indeed, is probably quite as much the cause of the formation of animal communities as the former. The American bison, or buffalo, formerly roamed North America in herds containing millions, yet it was itself the strongest and fiercest animal on the continent, and even had it required to combine for purposes of defence much smaller herds would have sufficed for the purpose. But whatever may have been the original cause of the formation of these vast herds, it was the mental principle in the bison which brought them about, and these irresistible combinations exercised a vast influence over the destiny of the bison, and might have endured for untold ages but for the advent of civilised man, armed with his deadly weapons of destruction, against which the bison's intelligence was powerless. Another animal formerly found in large numbers in North America—the beaver—also illustrates my argument. The beaver's social disposition and remarkable engineering capabilities have resulted in its bodily structure becoming eminently fitted for their exercise.

Animals which have a wide range will always be found to be intelligent. The sagacious elephant inhabits a large part of Africa, Southern Asia, and the Malay Archipelago, while extinct species of the race were dispersed over a much more extensive area of the earth's surface. The jaguar is one of the most intelligent of the larger beasts of prey, and its range in America extends from Patagonia to Texas. According to Wallace ("Travels to the Amazons," p. 316), "The jaguar, say the Indians, is the most cunning animal in the forest; he can imitate the voice of almost every bird and animal so exactly as to draw them towards him; he fishes in the rivers, lashing the water with his tail to imitate falling fruit, and when the fish approach hooks them up with his claws. He catches and eats turtles, and I have myself found the unbroken shells, which he has cleaned completely out with his paws; he even attacks the cow-fish in its own element, and an eye-witness assured me he had watched one dragging out of the water this bulky animal, weighing as much as a large ox." Taking the elephant and jaguar as types of intelligent animals of the larger kind, the rat, and especially the Norway

rat, may be taken as illustrative of the smaller quadrupeds. The mental faculties of the Norway rat are of a high order, and this animal has now established itself over a considerable portion of the civilised world. It is commonly asserted that it owes this extensive range to man's introduction, but certainly man has not purposely imported the rat into new countries; the rat, impelled by its own mental vigour and enterprising disposition, has followed in man's wake, and established itself in regions where man certainly did not want its presence. The rat possesses a great capacity for adapting itself to circumstances, and will, as occasion arises, eat fish, flesh, or grain, while the records of the New Zealand Institute show that in this colony it has developed a taste for shell-fish.

From amongst the birds we may take an almost cosmopolitan family, the crows, which are distinguished for their intelligence; in fact, one genus of the family seems to hold something like Courts of justice for the punishment of offenders; and these birds likewise display great capacity for varying their diet, which must be of material assistance to them in the struggle for life, some feeding on fruit, some on insects, and others on carrion.

If we turn to the denizens of the ocean, the Cephalopods, which are the most intelligent of the molluscs, have a world-wide distribution, while, in point of geological time, their remains can be traced as far back as the Cambrian formation.

The sudden incursion of many varieties of foreign animals into New Zealand would have furnished an interesting test of the power of the native fauna to meet the invasion but for the circumstance of its being accompanied by the arrival of large bodies of civilised men, whose wholesale destruction, not only of the indigenous animals but also of their food and shelter, is beyond the power of the native fauna to resist. Yet, were it not for the actual direct destruction of much of the native fauna by the colonists, the intelligence of quite a considerable number of our New Zealand birds is apparently sufficient to have enabled them to survive amid their changed surroundings and new competitors, although in reduced numbers. The kea, kaka, weka, parroquet, the different species of hawks and ducks, the kingfisher, tui, fantail, wax-eye, cuckoo, and swamp-hen, all seem able to hold their own against everything but the gun and other means used by men to destroy them. All of these birds are intelligent, and some highly so. The kea's suddenly developed carnivorous propensities, which have so often been commented upon, prove that it possesses an adaptable nature well fitted to cope with novel conditions of life. Mr. Green, in his work on "The High Alps of New Zealand," gives his

own experiences of the kea's intelligence. While camped upon the lower slopes of Mount Cook he and his companions were troubled by three keas, one of which he finally managed to kill with the blow of a stick; and a second, which seemed curious about the fate of its companion, he also contrived to strike on the back, but without killing it. Mr. Green proceeds, "The wisdom of these keas was remarkably illustrated by the readiness with which they profited by this lesson concerning a new source of danger. Up to this time we had had no difficulty in approaching and shooting them with the gun; after this incident they never let us come within range. The size of this parrot's brain when compared with that of the ducks which we shot was a source of frequent comment as we prepared them for the pot, and the deficiency of brain-power in the ducks was demonstrated not only by dissection, but by the slowness with which they profited by the lessons of experience." I do not, however, agree with Mr. Green's low estimate of the intelligence of our New Zealand ducks.

One of the most remarkable problems encountered by the student of nature is the cause of the disappearance of innumerable forms of animal life which once tenanted the globe. They culminate, in numbers and diversity of structure, at certain epochs, and then disappear from the world's life-history, sometimes suddenly (although the suddenness may be only apparent) and sometimes gradually. The dinosaurian reptiles, which formed such a conspicuous feature of the Mesozoic fauna, may be taken as an example. Judging from the fossil remains which have been exhumed in many countries, these huge and often strangely shaped creatures must at one time have ranged over a large portion of the land-surfaces of the Northern Hemisphere, and been very abundant. Many of them were of gigantic size, far surpassing in magnitude any land animal now existing. One, the Atlantosaurus, whose remains have been discovered in the Jurassic deposits of the Rocky Mountains, measured from 80 ft. to 100 ft. in length; others 50 ft., and so on. Their skeletons, too, are of the most massive description. It would seem as if no enemies outside of their own race could successfully assail such monsters, and that changed surroundings could make but little difference to them. Nevertheless, at the close of the Mesozoic period the dinosaurs vanished, one and all. What was the cause of their sudden effacement? Some inquirers have attributed it to the failure of a sufficient supply of food, but there is no actual evidence to support such a theory, and it seems inherently improbable. Most of the dinosaurians were vegetable-feeders, and the Tertiary period is marked by abundance of vegetation. Moreover,

looking at the reptilian nature of the dinosaurs, it is quite possible that, like many modern reptiles, they were slow digesters and of sluggish habit, and that the quantity of food which they consumed was not so great as their size would suggest. Nevertheless, the dinosaurs passed away. They proved unable to accommodate themselves to the changed environment, and why? I think the explanation is to be found in their low intelligence. The crania of these animals show that the brain-cases are small—a sure indication of limited intellect. Physically their frames may have been capable of adjustment to suit an altered environment, but the brain-power necessary to initiate the adjustment was lacking. They were unable to change their old habits of life.

The same cause will probably explain such apparent anomalies as the entire disappearance of the mammoth from Northern Asia, while its near congener, the elephant, still survives in the south of that continent, although the mammoth and the elephant were once contemporaries. Heilprin thus propounds the problem: "Both [*i.e.*, both elephant and mammoth], as far as we are permitted to judge, appear to have been in harmony with their surroundings; vegetable-feeders, they inhabited regions of sufficiently luxurious vegetation, the one provided with a shaggy coat of hair to protect it from the rigours of the frozen north, and the other, more nearly naked, suited to a home where little or no protection from climatic extremes was necessary. Both, again, were inhabitants of regions where a struggle against the attacks of savage carnivora was a part of their existence, and if any advantage favoured the one above the other in such internecine warfare it was on the side of the northern species." But if we assume that the mammoth was less sagacious than the elephant, that it possessed a less flexible mind, a more sluggish disposition, less capacity for adapting its actions to changed circumstances, the mystery is explained, and we can understand how, as the environment was transformed with the passing ages, the mammoth disappeared while the elephant survived.

Viewed from a mental standpoint, the apt phrase "survival of the fittest" acquires a peculiar significance. It is impossible to discover the life-history of a species from its mental powers, or to form a just estimate of the part played by any particular animal in the long procession of life without taking into account the peculiar mental capacity of the species as well as of the individual animal. It may be, also, that what I will term the collective mind of a species exhausts its powers of adaptation in the course of time, and that it then refuses any longer to respond to the pressure of outward

stimuli. Experience teaches every man that his own mental capabilities are confined within certain limits, and while mankind has accumulated vast stores of knowledge by the acquisitions of successive generations, there is no reason to suppose that men possess greater mental capacity now than they did in the days of the ancient Greeks and Romans. We know, too, that nations once intellectually powerful have ceased to be so. Bain has striven to prove that the reason why man's mental powers are limited is because the number of nervous elements by means of which the mind acts in the human body is necessarily limited; and whatever of truth there may be in this theory will apply also to the lower animals. There is an old age of the species as well as of the individual, and the time comes when the species can learn no more.

Before one species can be transformed into another, however gradual the transformation, there must at some stage be a new mental departure. Before the reptile could have been converted into a bird the reptile must have manifested bird-like desires. Before the ancestor of the ant could have taken the first step which ultimately led to the present social organization of this insect it must have manifested a desire and aptitude to live and labour in common with its fellows, and this desire and aptitude, gaining strength through long generations, has not only produced a complex social economy which is truly remarkable, but likewise resulted in the physical organization of the insect being fundamentally altered to facilitate division of labour. The same observations apply to the honey-bee. In both cases we must ascribe the origin of the special physical development of the insect to its peculiar mental organization. It has often been urged as an argument against Darwin's theory of development that slight modifications of bodily structure could seldom be of any use to an animal, or serve to originate novel structures. No doubt this is true if we merely regard such modifications as of themselves assisting the animal in the struggle for existence, but if we view them as means whereby individuals with a slightly different mental character from the rest of the species can give vent to their idiosyncracies, such modifications assume a greater importance. They may be of no consequence in an animal of the ordinary mental capacity of its race, but of great importance to one possessing individuality of character.

The climbing-perch (*Perca scandens*), of Tranquebar, climbs the fan palm in search of certain crustaceans upon which it feeds. When climbing it suspends itself by its open gill-covers, deflects its tail laterally upwards, so as to bring to bear upon the bark some little spines with which its anal fin

is provided; it then pushes itself upwards by straightening the tail, while it closes its gill-covers so as not to prevent progress, and so on. Now, any perch with unusually large gill-covers or a more muscular tail than ordinary would get on best in this new pursuit; but before such a modification of structure could be of any use some particular perch or variety of perch must have been strongly moved with desires which led it to depart from the ordinary habit of its kind and to leave the water and climb palm-trees. In Australia rabbits have learned to climb trees—a habit which, if it becomes hereditary, may give rise to a new species of rabbit.

The varying habits of different species of spiders will illustrate my argument. There are spiders which construct webs for the capture of prey; spiders which do not construct webs, but make nests below the surface of water, and there lie in wait for their prey; others hunt their prey on the land; others, again, make nests provided with trap-doors, and so on. All these spiders with different habits likewise differ in their physical structure, and form well-marked species. Can it reasonably be doubted that the cause of their original divergence from the common stock was the mental idiosyncracies of individual spiders leading them to strike out new lines of life for themselves, their bodily structure and habits, in course of time, becoming fitted for the capture of prey in different ways? If it be conceded that animals do possess mental faculties, and that their actions are, if only to some extent, controlled by those faculties, it seems to follow as a necessary consequence that the mind of the animal must play a conspicuous part in the evolution of a species.

In the foregoing remarks I have opened up a large subject, to the further consideration of which I may invite the Institute's attention on some future occasion. You will, of course, perceive that, if my views be correct, a cause which has materially influenced the development of animals is absent in the case of plants, although evolutionists have hitherto dealt with the development of animals and of plants as if the two had proceeded on similar lines.

ART. XXX.—*The Tohunga-Maori: a Sketch.*

By S. PERCY SMITH.

[*Read before the Wellington Philosophical Society, 8th August, 1899.*]

WE have all heard of the Maori *tohunga*, or priest, and many, no doubt, have formed some ideas of his functions. If we want to know something more about him, however, there is no work that I know of in which this information can be found. It is true there are references to the subject scattered through many works on New Zealand, but nowhere is anything like a comprehensive account to be found; nor does this paper pretend to be anything more than the briefest sketch. It may prove of interest, however, if we bring into focus some brief notes such as may be gleaned from a study of the people of whom the priest was so important a unit.

We shall never know a very great deal about the priesthood of the Maori race. From the very nature of the subject there are, and always have been, great difficulties in penetrating the dense atmosphere of mystery that surrounds their doings. The outward form of their observances has been seen by many, but the inner meaning and origin of their ritual will never be completely known to us. It must be remembered that the priests were a sacred class, and that their knowledge was guarded with extreme care, only to be taught to those of their direct descendants who were worthy and might be trusted. The extremely sacred character of all the ritual and much of the learning handed down from generation to generation prevented its communication to our own race, because white people, according to Maori belief, were not sacred—that is, they had no system of *tapu* such as the Maori had, nor did they hold things *tapu* to the Maori in any sort of awe or respect. Hence it came to be considered that the generality of white people were not fit subjects to whom these sacred things might be imparted.

It arises from this that those who had the opportunity afforded by daily intercourse with the Maori race, in the days when there still existed many of the *tohungas* of a high class, were not trusted by them except in a very few instances. It was, moreover, the business of the early educated white men to counteract and destroy the influence of the priests as inimicable to the tenets of the religion they themselves taught. Under these circumstances, it is obvious that the Maori *tohunga* would not be communicative. Moreover, in the days of early contact between the Maoris and men of the white race the knowledge we now possess, that other races—neither

white nor what we call civilised—-were possessed of systems of religion and ethics of a high character, had hardly dawned. It was the fashion then to set all such things down to the work of the devil, only to be approached with a view to their extinction. Could any one in those early days have secured the confidence of the old *tohungas*, it is believed that vast stores of knowledge would have been disclosed that would have thrown a flood of light on the origin of the Polynesian race, their religion, and their ritual. But the opportunity was lost, and when men of our own race appeared who could sympathize with the old *tohunga* there were few or none left in the land. It is true that there have been *tohungas* amongst the Maoris up to late times—indeed, there are still a few left alive; but these are a degenerate crew, who would not have been worthy to take their place amongst the learned men of yore. They have become degenerate through their environment. They no longer possess the powers of old, because they have lost belief in themselves, in the same manner that the people have lost faith in them.

It is probable that Tuhoto, who was buried in his house at Wairoa Village by the eruption of Tarawera in 1886, was one of the last specimens of the *bonâ fide tohunga* of the old school. He lived for seven days in the ruins of his hut without food or water, and with no means of escape, until he was dug out by some of the white people. I saw him a few hours after he had been rescued, a decrepit old man, whose years must have approached a century (he was in the prime of life at the taking of Mokoia Island in 1823), with white and matted hair and beard, and indescribably dirty. He lived but a few weeks after his removal to the Rotorua Hospital, and, it is said, the contamination he suffered when his matted locks were shorn was the immediate cause of his death. This may well be believed when we reflect on the extreme sacredness of the head amongst all Maoris, and of the *tohungas* in particular. He would feel that he had been *whakanoa*, or made common, and that his personal *tapu* had been destroyed. This, preying on his mind, would kill him.

But whilst there are none of the real old *tohungas* alive in the present day, there are many old men who have in their younger days been educated as priests. The disturbing element of Christianity has, however, caused them to forget most of what they learnt. Still, it is from these men that we may expect to learn something of the old ritual and *karakias*, or incantations. To those they take a liking to they are communicative to a certain extent, but the information they have to impart is always given with many depreciative remarks on the old forms, and with evident fear that they will be laughed at.

If we believe—and I think there is no longer room to doubt it—that the Polynesians came originally from India, or dwelt for a long time in that country, we may expect to find amongst some branches of the race a certain amount of the knowledge of what, in Europe, is termed the Eastern culture, but which we from our position term Western. Some slight indications of the almost transcendental powers of the Indian people ought to be found amongst the Polynesians. A few traces of these will be alluded to shortly. But thinking, as I do, that the Polynesians were in India before the Aryan irruption, and that they gradually gave place to the latter after a contact of no long duration, the amount of knowledge the Polynesians retain will be found to be much attenuated, and interwoven with their own peculiar cult, which is probably just as old as that of the Aryans. Contact between the two peoples, first as enemies, afterwards as neighbours, and again as enemies, must, however, have allowed time for Aryan influences to affect the Polynesians, and some of these influences may still probably be seen amongst the latter people.

First let me say that the earliest record I have come across of the existence of a priesthood amongst any of the Polynesians is contained in the Rarotongan traditions, of which I was so fortunate as to procure a manuscript copy the year before last on my visit to Eastern Polynesia. The reference to it is not an extensive one, but the fact is mentioned in the mythical guise so common to these very ancient traditions. Whilst the people were living in Atia-te-varinga, the most ancient country of which that branch of the race has cognisance, the priests are shown to have done certain wondrous things, besides having functions to perform in the elections of the ruling chiefs, or *Arikis*. I have attempted to show in another place* that Atia-te-varinga is India, also called in the Rarotonga dialect Avaiki-te-varinga. This is the country in which the race originated according to those traditions; and here we find at this early date a priesthood already developed and acting in its sacerdotal capacity in connection with the ruling power. Trusting to the genealogical tables, the date may be fixed at about the year 450 B.C. when these priests are first introduced to our notice. The important functions they there performed have been continued uninterruptedly down to the present day; for, whatever the source of the traditions may be, the mention of the priests is frequent. They were the astrologers, magicians, poets, historians, often warriors, and, not least important, the navigators, where the great knowledge of the stars they

* "Journal of the Polynesian Society," vol. viii.

possessed enabled them to guide their vessels from end to end of the Pacific, and even to the antarctic regions. They represented the navigating lieutenants of modern days. The *tohungas* were also the seers, as well as doctors of old. They combined with their astrology a considerable amount of astronomy, giving names to all the principal stars, besides many constellations. There are indications too that they were acquainted with the fact that the earth was round, or, at any rate, that it was not flat. This would, of course, become known to them through their voyages, by the appearance of fresh stars as they progressed either north or south. The following quotation from the teachings of one of the Hawaiian priests will show this knowledge of the fact that different stars are to be seen to the south of the Hawaiian Group: "If you sail for the Kahiki [Tahiti] groups you will discover new constellations and strange stars over the deep ocean. When you arrive at the Piko-o-Wakea [which was their term for the equatorial regions] you will lose sight of Hoku-paa [the North Star] and then Newe, the Southern Cross, will be the southern guiding-star, and the constellation of Humu [the star Altair in the constellation of Acquila] will stand as a guide above you." Amongst the Maoris the names of several of the navigating priests who guided the fleet here in about the year 1350 have been preserved, and it is known from tradition that α Centauri was one of the stars they steered by.

The *tohungas* shared, in common with all, the poetic faculty, some of their poems being very fine in the original, but generally extremely commonplace in the translation, according to our ideas. But, then, we generally lack the knowledge of their ancient history, allusions to which constitute the charm to the Maoris themselves. One of the finest compositions in the language is the "Lament" of Tu-raukawa, a priest who flourished thirteen generations ago, but which has come down to the present generation—being handed on from father to son—and is still sung with extreme pleasure by many of his descendants. It is these allusions to their ancient history that served to keep alive the interest in and knowledge of the doings of their forefathers.

Perhaps the most interesting duty of the *tohunga* was that of the historian. With many branches of the race there was a special class of the priesthood that was charged with this branch of knowledge. I do not think that this system obtained in New Zealand, but that all priests were equally versed in the tribal and national history, as, indeed, were all the chiefs. The national records of the Polynesians, as every one knows, were preserved orally, and handed on from father to son with due ceremony and appropriate prayers. The powers of memory in races which have no written records are

acknowledged on all sides to be enormously superior to ourselves, for instance; and hence the history of the people was retained with the greatest accuracy and with surprising detail. This fact, however, is not sufficiently known to those who have not had experience of it. It was with wonderment that I once took down from an old Maori friend of mine 164 songs which he knew by heart. It was only necessary to quote one of the lines at any part, and he would sing the rest of the song quite correctly, just as he had dictated it. Another Maori friend of mine has written out 108 songs, whilst an old man of the Urewera Tribe has actually dictated to Mr. Elsdon Best over 380 songs, *karakias*, &c.; and he could generally tell the history of them, and who was the composer. These are feats that we, with our artificial memories, are incapable of. It was by memories such as these that Polynesian history has been preserved.

But in collecting their history care has to be exercised as to the source from which it is obtained or it will not be acknowledged by the tribes to whom it relates. Of this I will give an illustration. Sir George Grey's "Polynesian Mythology" is generally considered a standard work on the traditions of the Maoris. Now, the major part of this book deals with the Arawa traditions. These were written out by Wiremu Maehe-Te-Rangikaheke, who was at that time about thirty-five to forty years old. But Wiremu had never been educated as a priest, and consequently many old men of the Arawa Tribe will tell you that his work is a *pokanoa*, or unauthorised proceeding, and not correct, inasmuch as it leaves out much detail, and actions are frequently credited to the wrong individuals. They have told me this themselves. This book must be looked on, therefore, as an outline, the detail of which is subject to correction. These remarks will not apply to other parts of the work, for, as far as is known, they were obtained from the proper authorities.

There were rivalries and jealousies always existing between the priests of different tribes, and the young people had constantly impressed on them the necessity of adhering to the teachings of their own priests as being the only orthodox history or ritual; all other was wrong, and therefore dangerous. Hence we find at the present day the traditions of different tribes varying very much from others. I do not think this was always so. There was a time in the history of the race when the old beliefs and history were taught at great gatherings, when chiefs and priests collected from the far-distant isles of the Pacific to a central spot, and there the history was recited, and a vast number of ceremonies performed the faint recollection alone of which remains. This was the period of the original *wharekura*, or house of learning, which, in its New Zea

land form, has been described by Mr. John White. Here were to be found the *whare-karioi*, or houses of amusement, in which, no doubt, originated the *Arioi* societies of Tahiti—societies of strolling players that passed from island to island and acted scenes from their history, accompanied by much debauchery and many strange customs. These people were priests and historians, and the most learned of the race. But these institutions were of far greater antiquity than the time that the Maori ancestors sojourned in Eastern Polynesia; they were brought with them from distant India, where, according to Rarotongan tradition, they were first initiated by the great king or chief Tu-te-rangi-marama in the fifth century B.C. This gathering-place in Eastern Polynesia was at Raiatea, of the Society Group. Here came lordly chiefs in their gaily decked canoes, with flying streamers and drums beating, accompanied by large retinues of chiefs, warriors, priests, and servitors. Tradition says that from far Uea, or Wallis Island, in the western Pacific, to Rapa-nui, or Easter Island, in the far East, the people gathered to these meetings. They took place at Opoa, in Raiatea, the most sacred *marae*, or temple, in all Polynesia, and from whence stones were taken to other islands with which to found other *maraes*, to serve as visible connecting-links with this most holy of places. Opoa, in Raiatea, was the Polynesian Mecca. Tradition seems to infer that these gatherings broke up after a time, owing to the hostility of two factions, the Ao-tea, or eastern people, and the Ao-uri, or western people, resulting in murders, wars, and all kinds of evils. The origin of these troubles was due to the priests, and the inference is that schism in the common doctrines of belief was the cause.*

As yet we cannot fix with any certainty the date of this disruption, because the Tahitian accounts are not yet given to the world; but from the indications in Maori history it was probably about the end of the thirteenth century. From this period downwards it may probably be predicted that considerable differences in the rituals, beliefs, and histories of the eastern and western branches of the Polynesians will be found by any one who will pursue the subject. But that time is not yet. The Maori branch of the race belongs to that division referred to above as the Ao-tea, or eastern people. The meaning of these two distinctive terms, "Ao-tea" and "Ao-uri," is the light and dark world, derived from the sunrise and sunset.

I have said that Maori priests were warriors. With a warlike people like the Maori this was only natural. There

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* Much of this I learn from Miss Teuira Henry, one of the first of Tahitian scholars.

are innumerable instances of priests leading their tribes in time of war, and I think this is a custom dating from very ancient days. If this is so, it is obvious that if any crushing defeat overtook one of the tribes engaged in the wars many of the priests would be killed, and with them would perish much precious knowledge. There are indications in Maori history that some great catastrophe of this kind has overtaken their branch of the race at a period which may now be called ancient. It would lead me too far from the subject in hand to demonstrate this, but a close study of Polynesian traditions for many years has led to this—to me—inevitable conclusion.

Even when not engaged as a leader in warlike expeditions the priest had still very important functions to perform. As *mata-kite*, or seer, he had invariably to foretell from the signs and omens whether the result would be favourable or not. By these signs the chiefs were guided in their actions. Everything connected with war was *tapu*, or sacred, from the first preparations of the war-party to the return home, when the priest removed the sacred ban from all who had been engaged in the campaign. The reason of this was that man himself was sacred—he was the living representative of the mighty Tu (god of war), and hence the shedding of blood was a desecration of the *tapu*, and had to be cleansed, in the persons of the shedders, by appropriate incantations and ceremonies. No step during the campaign would be taken by the leaders without consulting the priests, and there is little doubt that hints as to the wishes of the chiefs judiciously given affected the utterances of the priests to the multitude. On starting from their homes the warriors all gathered at some stream which had been used for the same purpose from time immemorial, and there the *tohi-taua* was performed by the priest over every man, all kneeling on one knee at the side of the stream. With a sacred *karamu* branch, which was dipped in the water, the priest struck lightly the shoulder of each warrior, repeating at the same time a *karakia*, or prayer. If the branch broke in the operation that warrior would be killed in the ensuing fray; consequently they wisely stayed at home to assist in protecting those left behind. This ceremony is aptly called the "baptism of war," which, indeed, is the translation of the term *tohi-taua*. After the day's march the priest decided on the camping-place by sticking his *turu-pou*, or staff, into the ground, around which the warriors slept. Instances are known in which an imminent defeat has been turned into a victory by the priest driving his staff into the ground and calling on his tribe to die or conquer there.

Not a single *ika-a-Tu*, or fish of the god Tu (in other words, a slain man), might be eaten until the priest had first

performed the rigorous ceremonies connected with the removal of the *tapu*. Certain parts of the body were reserved for his special consumption, such as the heart, &c. He was ever at hand to communicate the will of his particular *atua*, or god, under whose protection, of course, the war-party was for the time being. On the return home his services were again in requisition to remove the *tapu* from the whole party, before which none of them dare come near their relatives and friends.

From birth to death the priest was in constant requisition to perform some ceremony connected with the every-day incidents of life of the Maori. Soon after birth—the number of days varied from tribe to tribe, but generally about the eighth day—the child received its name. This naming was called *tua* or *tohi*, and here the priest officiated by the utterance of appropriate *karakias*, and officially named the child. In cases of sickness he was applied to to ascertain the cause. In most cases this was set down to the infringement of some of the innumerable laws of *tapu*, or to *makutu* (witchcraft) by an enemy. As wizards, either to inflict injury on another or by appropriate means to avert the witchcraft of some other person, the priest had immense powers. To this subject I shall return later on. Again, at the marriages of people of distinction the priest was present, and used many *karakias*. It is generally said that there was no form of marriage amongst the Maoris. This, however, is only true of common people; with chiefs there was much ceremony and many *karakias*. When death came to take the warrior to his last resting-place beyond the *reinga* the priest had very important functions to perform. Probably we have more *karakias* preserved connected with the death ceremonies than others. They are evidently very ancient, and frequently couched in language which is extremely difficult to understand. My belief is they are so ancient that the meanings of the words have completely changed since they were first embalmed in these old *karakias*. The mere translation of them, therefore, even when this can be done, probably does not give the meaning intended originally, or even those known to the priests. The Maoris themselves are generally ignorant of the meaning at the present day.

Something must be said of the education of the priests. Little will be found on this subject in the works of those who have treated of Maori customs, therefore I must place before you the little I have myself gathered. Here, again, we are met with the difficulty that the esoteric meaning attaching to the ceremonies is lost. There can be no doubt that each step had a well-defined meaning at one time to which very great importance was attached.

It was, I believe, a rule that the priesthood descended from father to son, generation after generation. It was the duty of the father, or sometimes the grandfather, to teach the young pupil. Failing either of these the uncles would do so; but in such cases the remark applies more particularly to the education of chiefs rather than that of the priests. There are cases on record wherein the pupil went to priests of another family, or even another tribe, to acquire their education, and presumably this was in default of either father or grandfather. In such cases as last mentioned the inference is that the whole of the teacher's knowledge was not communicated to the pupil. There were certain branches of knowledge and *karakias* that were family or tribal property, and these were not communicated. Amongst the warriors of the tribe also there were certain things that belonged to the individual which were not communicated to others. Such were the *ki-tao*, or *reo-tao*, the prayers said over weapons to make them efficacious—these were secrets only known to each family. Several of this species of prayer have been preserved, for after the old-fashioned weapons became obsolete there was no longer any objection to the prayers becoming known.

It was at about the age of twelve that boys were first taught. So far as can be gathered, the first lessons took place in the *whare-maire*, which was a carved building used especially for the recitation of the tribal history, and which was very sacred. Here the origin and history of the tribe was taught, the genealogies of the ancestors down to the time of teaching—always considered very sacred—were recited, and tribal wrongs that required a blood vengeance enumerated. There were initiatory ceremonies connected with the first entry of the pupil into the *whare-maire*, but these I am not acquainted with, beyond that there were special *karakias* for the purpose. During the whole time of teaching the pupils were not allowed to leave the precincts of the house, food being brought to them by the women and left at the palings surrounding the house, for no female was allowed to enter the house whilst the course of instruction was proceeding—it was very strictly *tapu*. It is clear that certain *karakias* were also taught in the *whare-maire*, but some, I believe, were only learned in the woods and mountains, away from all habitation. These were probably some of the most powerful incantations pertaining to the priesthood alone. Here let me say that the knowledge of *karakias* was not confined to the priests; it was common to all, but there were certain classes of *karakias* used by the priests alone.

Accounts vary as to the length of each session of teaching; but they were not of long duration, probably not more than ten days at each sitting. The effect of the *karakias* on the

pupils was supposed to be so powerful that one lesson is said to have sufficed on each subject. I have repeatedly been told that a long *karakia* would be learnt after once repeating, and learnt perfectly too. Here comes into play the wonderful memories of all savage races. It was considered as a matter of vital importance that the words of the *karakia* should be repeated without the slightest mistake; the dropping of a word, or the introduction of one not originally there, was fatal to the efficacy of the prayer. The belief of the old-time Maori was that such a mistake, or *hewa*, reacted on the reciter himself, and I have been told that in some of the very sacred ones such a mistake would cause the priest's death. Even a deviation in the pattern of the carvings made accidentally is said to have caused death. It will be seen from this that many of the *karakias* must be of immense age, and that it is probable we have at this day many that were in use before the Polynesians entered the Pacific.

On the conclusion of the teaching a special kind of *karakia* was repeated by the teacher, called a *karakia-pou*, the object of which was to indelibly fix in the memory of the pupil the various things he had been taught. There were ordeals also that the pupil had to undergo to prove his proficiency, but of these my informants were chary of telling me. The final one, called *whakangau-paepae* was of a nature I can scarcely allude to here.

But of some of the ordeals connected, I believe, with the education of the young priests a little is known. In mentioning them they will be given as told to me; not that I give full credence to the accounts received, but adduce them rather as illustrating the firm belief the Maoris had in them. These ordeals appear to have varied from tribe to tribe, which seems only natural when we come to know that the Maoris did not all migrate to New Zealand at the same time, nor did they come from the same place. With the Arawa Tribe, after the pupil had been duly *poua*, or had the lessons firmly fixed in his mind, he was taken by the priest to the *tuahu*, or altar, generally situated near the village, where a stone was set upright in the ground, though more generally the *tuahu* was represented by a rough enclosure of poles. Here the pupil, after providing himself with a small flat stone about 1 in. in diameter, was directed to cast it at the *tuahu*. If the stone broke the teaching was considered not to have been successful, and the pupil was put back until another session. If the stone did not break, then a further trial was made, as follows: The pupil, or *tauira* (which is the proper Maori name for one under instruction), took a stone in his hand—a hard, smooth, sound stone—and then by the use of a *karakia* called a *hoa* he would shiver the stone into fragments without injuring his

hand. It must be understood this operation is accomplished by the mental operation of willing and by repeating the *hoa*, not by a physical effort. The word *hoa* we have no exact equivalent for in our language. It means in one sense "to charm," or "to destroy by the power of the will," the spoken words of the *hoa* acting as the vehicle connecting the will-power with the object. The action of our Lord in destroying the barren fig-tree would be, according to old Maori belief, an exact illustration of the word *hoa*. The word is of very common use in old Maori narratives, always with this meaning of an exertion of will-power generally for the destruction of some animate or inanimate object, or to affect its state of being. Sometimes a flying warrior will use a *karakia* called a *tapuae* to hasten his flight. This is the use of the *hoa* in a sense beneficial to himself. Again, he will *hoa* a flying enemy in order to retard his flight; but the meaning is always the same, and the efficacy of the *karakia* thoroughly believed in by the old Maori.

If the *tauira*, or pupil, succeeds in the above test of his powers he next is directed to try them on some animate object, such as a dog or a flying bird. The process is the same in both cases, and, according to the Maoris, the bird was always killed if the *tauira* was proficient.

After this comes the final test, by which the *tauira* shall prove to his teacher that he is adept and accomplished in the highest art of the *tohunga*. From what follows it will be seen that this last ordeal is a very severe one. We may believe in it or not, but the old Maori had implicit faith in it, and fully believed their *tohungas* capable of exercising the power. The *tauira* was told that he must now exercise this power of willing to death on some near relative of his own—an uncle, aunt, brother, or sister, but never a child of his own, and, I think, never a parent. The selection of a relative was made in order that the pupil might thereby show that, in the exercise of his powers, he rose superior to natural affection—the dominion of the teaching priest was so powerful over the *tauira*, together with the delight felt in the acquisition of such extraordinary power, and the dread that it was known to excite in the multitude, were sufficient, say my informants, to overcome all feelings of love and affection towards the victim. The extraordinary thing is that in a race whose strongest passion was love of revenge these alleged exhibitions of the *tohungas'* powers on human beings never led to retaliation. So say those of their own race.

I have mentioned the *karakia-pou*, or incantation to indelibly fix in the memory of the pupil the information taught. The word *pou* also has the meaning of "teaching"—that is, in its higher forms — accompanied by all the forms and ob-

servances considered necessary in such cases. But there are other and very peculiar methods of fixing in the memory the lessons taught, and which were considered very efficacious in certain circumstances. If from any cause the son of a *tohunga* had not been fully educated, or, possibly, in cases where the father's knowledge had not been completely communicated until just before his death, it was the custom for the *tauira*, or pupil, after being taught all the father or teacher had to communicate, to bite the teacher's great toe. In other cases he would be directed to bite off the tip of the teacher's ear. In both cases the teaching was thereby supposed to become fixed for ever in the pupil's mind.

To those who have heard the stories of the wondrous powers of the *tohungas* of old, told with all the circumstantiality of name and place, there comes a questioning doubt as to whether, after all, there is not something in them that lies beyond our ken—whether this old old race has not preserved a knowledge of forces that we have yet to acquire. However this may be, it is obvious that the belief of the multitude in the enormous powers of the *tohunga* would in many cases act as if those powers were real. It is a matter of common knowledge that if a Maori fully believes he is bewitched unto death he will die. They are peculiarly susceptible in this direction. They have extraordinary powers of belief. They are people in whom faith is a reality.

This brings us to another branch of our subject. No one who has studied the matter deeply will find a difficulty in accrediting the old *tohunga* with some knowledge of hypnotism, telepathy, and other "isms" pertaining to that class of mental phenomena. Here their great powers of faith come directly into play, for, as is well known, these mental sciences are based on faith or belief. Many of the powers of the *tohunga* can doubtless be explained by hypnotism due to conscious or unconscious "suggestion."* *Makutu*, or sorcery, as practised by the Maoris, is largely the effect of hypnotism and suggestion conveyed by telepathy. Let a Maori once be told that some one has bewitched him—has exercised the dread power of *makutu* over him—and the suggestion, falling on ground prepared by faith, will rapidly effect its object. If there be a *tohunga makutu*, or *whaiwhaiā*, near, the sufferer will apply to him to use his powers to counteract the effect, and should the counter-suggestion be sufficiently powerful (or, as the Maori would put it, if the *karakias* are potent enough) the object of the *makutu* will recover. Is not this hypnotism, or some form of it?

I do not propose to touch on *makutu* any further, but it is

* I use the word "suggestion" in its technical sense.

a subject on which a volume might be written. It seems to me that the mysterious word *ihi* found in several combinations in Maori *karakias* will be found hereafter to represent their idea of hypnotism.

As to telepathy, there are several incidents known—some of them to European eye-witnesses—in which the old and learned Maori could influence persons at a distance—could, for instance, by conveying a telepathic message, bring back from a distance some relative or friend. All of this is accompanied by *karakia* as usual, which in this case is called an *iri*. It is known to be expressly used for the purpose of causing a meeting between distant persons, one of whom desires to see the other. I have had such a *karakia* applied to myself, and my friend was confident that we should meet soon; as a matter of fact we did meet, but I am afraid the necessary faith on my part was too much wanting to allow me to set down our meeting to the efficacy of his *karakia*, whatever he may have thought.

In all these things the *karakia* was a necessary adjunct. It represented the demand made by the Polynesian order of mind for some ostensible outward sign connecting cause and effect. Ask any old Maori what is the cause of deeds effected by incantation or invocation, and he will tell you it was the *karakia* itself, the form of words used. The mental operations antecedent to or giving rise to the *karakia* are not known or hinted at. In this I think they show that the origin of the *karakia* has been lost—that the real mental processes out of which arises their forms of hypnotism, telepathy, &c., are now unknown to them, though in the far-distant past the two processes were not separated.

It has already been stated that the efficacy of a *karakia*, whether used by priest or people, consisted in the absolute fidelity with which the formula was pronounced. The mistake of a word was fatal. They were recited in a peculiar voice, partaking somewhat of the nature of our intoning, in which the words flowed on in an even and rapid stream, broken only by the necessity for taking breath. That was the usual procedure; but there are some *karakias* whose effect only followed the unbroken continuous stream of words from beginning to end. In this case a relay of priests would be ready to take up the words so soon as the first one's breath failed. It is to be regretted that so much of the meaning of these prayers has been lost. They are so full of allusions to things we have no knowledge of that their translations are often, to our ideas, meaningless. Their name is legion, and they were applicable to every event in life. In the use of these *karakias* on every occasion the Maori was probably one of the most religious races known.

In cases where communication between gods and men was necessary, as it was when decisions on public events were desired, the priests were naturally the mediums. In war more particularly their services were in constant requisition to declare the will of the gods, or the nature of the omens and predictions derived from the utterances of the gods. The belief was in such cases that the god entered for the time into the body of the priest, and through him uttered words intended as a guidance for the people. Many such utterances have been preserved; they were in their nature frequently oracular, and so obscure that neither priest nor people could explain their meaning. Possibly this may be due to craft on the part of the priest, who, not feeling certain in his own mind as to the result, often conveyed the message in such form as to admit of more than one interpretation. It is quite clear from what we know of the relation of the priest to the gods, on occasions when communication was necessary, that they were for the time in a state of trance, or possessed—as they call it, *urua*. The process took some time; frequently the priest retired to his own dwelling, and there, by what process we know not, communicated, or pretended to do so, with the spiritual nature of the god. Let me say here that the so-called Maori gods made of stone or wood were not in reality gods, but merely their effigies, in which the spiritual god took up its abode for the time, on the intercession of the priest, in order to reveal its message. The Maoris were only idolators in the same sense as any other branch of the Polynesians. Their gods were spirits, though endowed with human attributes. Their idols or images were concessions to that faculty of the Polynesian order of mind which demanded a tangible representation of the unseen and spiritual nature of their gods. The priests often saw the gods in a trance, and on coming to themselves would declare the message to the people, often in the guise of a song, many of which are really pretty in the original.

When the priest was *urua*, or possessed by the god, he must have been a terrible object to look on, according to the many accounts I have heard. He was like a furious raging madman, his body and limbs convulsed, his eyes protruding, foaming at the mouth, giving utterance to strange tongues; sometimes rolling on the ground, at others rushing hither and thither with furious grimaces and frantic cries. These fits gradually died away, and were succeeded by a long period of utter prostration. I need not point out that in some of these features we recognise what is sometimes seen in trance subjects amongst ourselves, as well as in certain states of clairvoyance.

There were other methods of communicating with the gods

besides those that have been indicated, one of which was no doubt due to craft on the part of the *tohunga.* This was by ventriloquism, which was frequently practised by the priests, more particularly perhaps when communication was desired with a deceased relative rather than a god. The voice came in a kind of whistling supulchral tone, and this was supposed to be the natural tone of voice of the dead. It will be remembered that Judge Maning, in "Old New Zealand," gives a graphic account of such a communication with a deceased relative. In old times whistling was supposed to be offensive to the gods. In my young days I have often been reproved for whistling as likely to anger the gods.

In the early part of this paper I ventured to say that the Polynesians had retained some of the knowledge they brought with them from India, and which they probably acquired from some of the Aryan races. That they are acquainted with some of the feats of the Indian fakirs is obvious from their practice of the fire-walking ceremony, in which the priests took the leading part, always prefacing the operation by *karakias.* It is well known that the people of India can perform this feat, and that it is done at the present day. The Tahitians engage in it frequently, and I am assured by learned Maoris that their ancestors of a few generations ago could also perform the feat. I will here refer to a description of the *umu-ti,* or fire-walking ceremony, as performed last year in Rarotonga, in which a gentleman well known to most of us took part (see article by Colonel Gudgeon, Journ. Pol. Soc., vol. viii., 1899, p. 58; also Dr. Hocken, in Trans. N.Z. Inst., vol. xxxi., 1898, p. 667).

We have all heard of the mango trick as practised by the people of India, but I think it will be new to you that the Polynesians are equally acquainted with it. Whilst in Tahiti two years ago the following was told me by a middle-aged woman, a native of Raiatea, who was remarkably intelligent and well versed in the history and customs of her race. Her grandfather was one of the old *tohungas* of that sacred island of Raiatea, and my informant declared that she, as a child, had seen him perform the following feat: The people were gathered together on the occasion of some feast or ceremony, when the *tohunga,* calling their attention, plucked from an adjacent tree a green bread-fruit. This he proceeded to bury in loose earth before their eyes. After repeating certain *karakias* the people all saw the bread-fruit leaves sprouting from the ground where the fruit had been planted. As they looked they saw the tree grow until it reached to 8 ft. or 10 ft. high; then came the flowers, and finally the fruit. I cannot vouch for the truth of this as I did not see it, but I have no reason to doubt my informant—at any rate, to doubt her belief in

what she saw. It is no more wonderful than the mango trick of India, and I would suggest the explanation is the same. To my mind it illustrates a phase of hypnotism with which we European people are not yet acquainted—in point of fact, that the operator has the power of hypnotizing large numbers of people at the same time.

The priesthood was divided into classes, of which I believe there were five, but I have never been able to ascertain definitely what were the particular functions of each. The *ariki* or first-born son of some exalted line of descent was a priest, besides being the hereditary chief of his clan. He had peculiar powers and duties which none other could perform. It is true that the *ariki* might not be a man of wisdom or an able leader, but, nevertheless, he did not thereby lose his high position in the tribe, and at certain functions his presence and actual participation in the rites was essential. None other could perform them. It was the same with the first-born daughter of a long line of chiefs, called a *tapairu* (sometimes a *marei-kura*). She alone could perform parts of certain ceremonies, and hence was she a priestess.

In all work connected with constructions in wood, such as houses and canoes, &c., a priest directed the undertaking, from the first felling of the tree, which must be accompanied by *karakias* to remove the *tapu*, for trees were the offspring of Tane-mahuta, the god of forests, birds, insects, &c., down to the last part of the decoration. If it were a house, he must by means of his *karakias* again remove the *tapu* before the building could be occupied, by use of the *kawa-whare*, a *karakia* of which we have many examples, some of them very fine (in the original). I am inclined to think it was a special class of priesthood that undertook the duties connected with woodwork, and this agrees with the customs of Samoa and Tonga, where our word "*tohunga*" has more the meaning of "artificer" than "priest."

Tattooing, again, in former days was undertaken by the priest, and, needless to say, was accompanied by many *karakias*, and also songs. Several specimens of these have also been preserved. When the time came for the *tapairu*, or eldest daughter of a high chief, to be tattooed, a human victim, chosen from amongst the slaves, was sacrificed. This is one of the few occasions on which such sacrifices took place. The others that I know of were in the launching of a new canoe, in building a new pa or new house, when a slave was buried at the foot of the main palisades, or the *pou-toko-manawa*, or main pillar of the house. At the celebrated pa of Tawhiti-nui, near Opotiki, a skeleton was discovered at the base of each main post of the palisades not many years ago, when the pa was demolished.

I have mentioned the *tapairu*, or eldest daughter, as being in certain cases a priestess. There were other female priestesses also, amongst whom the *ruwahine* is an example, and she had certain special functions which could alone be performed by her. But of the female priestesses and their peculiar duties I must confess myself ignorant.

Amongst the many powers ascribed to the *tohunga* of old is that of influencing the dead. The following is an example of Maori belief in such matters, the story having been told to me by one who says that he witnessed the occurrence. The tribe had suffered defeat at the hands of their enemies at no great distance from the tribal home, and one of their *toas*, or braves, had been killed. The body was brought home, and there, as was the custom, was laid out in state dressed in all the finery of savagedom, in order that the relatives might wail over him in due form. The tribe were exceedingly anxious to ascertain by some omen connected with the dead warrior whether they would be successful in their next encounter with the enemy. The priest was communicated with, who promised to procure the omen desired. As the people squatted in a ring surrounding the corpse at some ten paces distant, the priest advanced a few paces from the body of the people, girded with a strip of green flax as his only clothing, and then recited *karakias*, presumably of a very powerful nature, with the intent to induce some movement in the corpse. Nothing disturbed the current of his incantations but the low wailing of the immediate relatives of the deceased, whilst all eyes were turned on the *atamira*, or bier, where the subject lay. At a certain part of the *karakia* the corpse was observed to *kori*, or move slightly to one side, at which a great cry arose from all present, and the deceased was adjured to return to his loving relatives. But nothing more followed. This movement was taken as a certain sign of future victory.

Now, all present certainly believed they saw the movement, which was nothing new to them, for the feat had often been performed before by their priests. Is there any natural explanation of this, or was it mere fancy and delusion? I will venture to suggest that it may be explained by the fact of the subject being in a state of catalepsy, and not really dead, and that the priest, by exerting his hypnotic power, with the aid of telepathy had conveyed so powerful a "suggestion" to the body that the cataleptic sleep was for the moment broken, and hence the movement. Presumably, had the efforts of the priest been continued the subject would have returned to life. I did not witness this, and therefore can only tell you the story as repeated to me. The one thing certain about it is the entire belief of a large body of people in

the phenomena they witnessed. The above scene occurred at Rotorua many years ago.

The next illustration of the hypnotic power—as I think—of one of the old priests is drawn from the same district. The priest in this case was old Tuhoto, who has been referred to as having been buried for a time during the eruption of Tarawera in 1886. A very eminent Englishman took part in the *séance*, but as he has never to my knowledge given any account of it I refrain from mentioning his name, and give the Maori account as related by a well-known chief, formerly of Rotorua, but now dead. Old Tuhoto had for years resisted the efforts of the missionaries to convert him to Christianity; indeed, I believe he died in the firm belief in his native gods, and never recognised Christianity. It was important that the old man should be converted, for he still had a large following of Maoris, who hesitated to abandon their old creed for the new. Accordingly the gentleman that I have mentioned visited the old man at Mokoia Island, Rotorua, and there had an interview with him, using his utmost powers of persuasion, which were great, to induce Tuhoto to come over to the *whakopono*, or belief. But without success; the old man was so wedded to his ancient doctrines that he declined all overtures. He finally said, "If you can do this I will become a convert." Picking up a dried leaf of the *ti* (or *Cordyline australis*), he held it at arm's length, and, saying a few words of Maori *karakia*, invited his visitor to look. Behold! the leaf was green, as if just plucked from a growing tree. The white man turned away, feeling that he was no match for the Maori *tohunga*.

That is the story of a Maori eye-witness, and, needless to say, he firmly believed that Tuhoto's power of *karakia* had effected the miracle. Is not this an illustration of the power of hypnotism as practised by the Maori *tohunga?* He was able, by so powerful a "suggestion," to cause his visitor to believe that what he saw was a green *ti*-leaf, whereas it was in reality a dry one, the colour of which is brown.

Many other illustrations of the powers of the old Maori *tohunga* might be adduced, but time is wanting. I have endeavoured in briefest form to indicate the strength of belief that the Maoris had in the wondrous powers of their priests. Some of their powers are explained by processes which we are only just acquiring some insight into. Others are quite unexplainable at present; but the time will come when investigation will probably show that what we look on now as absurdities have some foundation in fact, and are the relics of a very ancient system of knowledge.

Art. XXXI.—*Further Notes on Maori Skeletons and Relics brought to Light at Karaka Bay, Wellington.*

By H. N. McLeod.

[*Read before the Wellington Philosophical Society, 12th September, 1899.*]

Since the opening-up of Karaka Bay for residential purposes, which took place about two years ago, the excavation and removal of soil incidental to building and improvements has brought to light not a few interesting relics of the aboriginals who, at an earlier date, made this bay their habitat; and, judging from the number of bones unearthed in the different places, it must have been regarded by them as an attractive place. It may be that the facilities for fishing were great, and that the supplies of karaka-berries were abundant in their season.

Last year the Society had placed before it three or four small relics—a small stone chisel, a whale-tooth, a tattoo-scraper, as well as certain human bones, which, from their proximity to the buried remains of a fireplace and bones of birds and fish, seemed to suggest a cannibal feast. With the exception of the chisel and tooth, these were found at the entrance to a cave which is situated three hundred yards to the north of Taepakupaku Point.

Some two months ago, while some sandy soil was being moved in order to make a level surface, the bones of some eight skeletons were uncovered at a spot four hundred yards south of the point mentioned. They were found buried together, and not in the usual custom. The distance of the spot from the beach is a chain and a half, and the depth below the surface was about 1 ft.

Shortly after this, at the end of June last, while holes were being made for the planting of trees on part of the Harbour Board's reserves adjacent to the old pilot-station, a skull upright in the ground was uncovered. The crown was but 6 in. from the surface. The upper jaw was *minus* two front teeth, the rest being fairly sound. The rest of the body had been laid in the ground in a horizontal position, resting on its side. It had been treated in the usual Maori way, in that the legs were brought up close to the body.

Not far away was found a stone club of moderate size. Some days later the fine stone *mere* shown to-night was discovered near the same spot. A piece of greenstone, weighing 5¼ lb., which was undergoing the process of grinding, apparently for the purpose of forming a *mere*, is also shown. This was found at Karaka Bay, near the old pilot-station.

Art. XXXII.—*Inherited Instincts and Anecdotes of Domestic Animals.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute, 16th October, 1899.*]

Owing to my residence in various parts of New Zealand in the early days of the settlement of the country, and my occupation as a pioneer sheep-farmer in the days when boundary-fences and subdivisions of properties were unknown, I have had opportunities to observe the habits of our various domesticated animals when placed amidst surroundings such as were probably nearly akin to those formerly occupied by their feral ancestors. In this paper I will endeavour to describe certain customs and peculiar actions which some animals exhibit when thus ranging over a large extent of land, seldom interfered with by the herdsman or shepherd, which habits are undoubtedly inherited from their one-time feral ancestors.

The Horse.

One of the most interesting sights of long ago would be the hackney or riding stallion in charge of his herd of mares. At any time during the year he would allow no males, whether entire or otherwise, to come within sight of his harem, and if any such came within view he would charge out at a gallop to meet and fiercely bite them, tearing and bruising away great patches of outer skin and hair the breadth of a man's hand, and I have seen a large-sized gelding fairly lifted up several inches from the ground by the skin of his back as if held in a vice. When the assaulted animal could break away, flying in grievous terror, he would be pursued, and every now and again overtaken and bitten by the cruel teeth, which on losing hold would clap together like castanets. It seemed to me that intense fear caused the fleeing animal to lose a portion of his strength and fleetness, and his follower by an extra spurt would come up to him.

A chestnut entire, bred in Australia and imported to New Zealand about the year 1858, was in my possession for ten years, and was running in freedom with his mares during that time. His name was Jersey, and he looked after his harem with the greatest jealousy, with the single exception of a small bay mare (Fanny), whom he drove away, and who had to associate with a distant mob of colts and geldings; nevertheless, she produced a foal each season.

The horse, when collecting and driving his herd, is a grand

sight. He travels at a swift trot, with ears laid back, head and neck bent down, and nose close to the ground, almost between his fore legs, in which attitude he fills his mates with terror. With much swishing of their tails and other signs of fear (each one closely accompanied by her foal, who keeps alongside its dam) they all start away in a mad gallop, urged forward by their driver, who is then galloping from side to side on their outskirts, threatening the laggards and stragglers of the mob.

A peculiar habit of the horse—evidently a custom inherited from a far-away ancestor—is that when he leaves his mares to make an excursion round about in order to find other mares to add to his mob he will establish large heaps of his droppings (dung) at certain places, so that any person seeing these heaps would at once know that a stallion was running free at that place. This remarkable instinct or sexual custom, like similar customs amongst other animals, is to our ideas entirely useless, but they may at one time have served some useful end—for instance, I have noticed that a stallion living at a distance would never extend his beat within the boundaries occupied by the other, possibly being in a measure warned by these heaps of ordure.

The exactitude with which the animal would measure his distance when making a deposit was remarkable. On first coming up he would for some time smell the heap, as if obtaining certain knowledge of those preceding him; then he would step across the required distance and leave his deposit thereon with the greatest exactitude. This was evidently done with a special purpose, and was at times varied by staling on the heap, the horse never requiring to look around to calculate the position. This anecdote to some may seem out of place and scarcely worthy of mention, but I venture to assume that in the study of nature all such are worthy of record.

I once tethered a quiet mare overnight, and the next morning, being young and active, I coiled the rope and jumped on the mare barebacked and rode about a mile, to where our riding-horses were feeding, for the purpose of driving them in and catching those required for the work in hand. To my surprise, the old mare I rode became quite unmanageable, and carried me forward at her best speed, keeping well in the centre of the scurrying mob. The land in those parts at that time had a great deal of spear-grass and the prickly shrub called "wild Irishman" spread about, and this, added to the fact that the mare only had a rope around her neck, increased my difficulty in keeping a seat on my hurrying steed. During this exciting gallop I became aware of the fact that my favourite riding-horse (Ostrich) was closely attended by a small foal, a circumstance which, so far as my

experience tended, should have been altogether an impossibility. When we arrived at the house (we then had no stockyard, but kept a small slab of wood for each horse, upon which on like occasions a small sprinkling of salt was placed to encourage their homing instincts, for this situation was ninety miles inland) I examined the new foal, and it gradually dawned on me that my mount (Creamy) was its mother, which accounted for her wild excitement during my ride. The remarkable fact of this anecdote was that the gelding and the foal had established a strong bond of friendship, and were inseparable. Ostrich bit and kicked at the other horses, and would not allow the mother to claim her foal. Ultimately I took Ostrich for a two days' ride, and left the foal, expecting it to starve to death, for it showed great fear of its own mother, but when I returned the foal was well, and had accepted the attentions of its anxious parent.

About the year 1860 I rode some distance for flour, and I took a second mare and a packsaddle with me. The following day, when returning with 1 cwt. of flour on either side of the pack-horse, I was met by a three-year-old stallion, who took up a position in front of my mares, with head down and ears laid back, and I was unable to urge them forward. I then dismounted and collected some stones, and, by a few skilful shots, succeeded in driving the animal behind me; but unfortunately the two mares began at the same time to move homeward, and the horse, noticing this, galloped round me and took possession. I had the satisfaction of seeing my mares and the then greatly valued flour disappear at a gallop, leaving me to follow on foot in a dejected and sorrowful state of mind.

As most people are aware, the horse will show fear or surprise by trotting around with a high pounding action, with head held high, and neck arched, and mane flowing in the breeze, occasionally stopping and intently gazing directly towards the object of anxiety, and snorting or loudly blowing through his nostrils. Our horses greatly feared even the smell of three she asses which were owned by a neighbour; so much so that without the donkeys being in sight it was difficult to ride them close to this person's abode, the small shrubs and hedge being evidently considered lurking-places for these dread animals. One time during my absence this neighbour thought it a favourable opportunity to secretly obtain the services of my horse Jersey to raise mules. He managed to get Jersey into the same stockyard with the donkeys, when he broke away, urged by intense fear, and, jumping the 7 ft. fence, took across country as hard as he could lay legs to the ground. This came to my knowledge years after the occurrence of the episode.

In the old days, when the whole country was unfenced, except in the vicinity of a town, horses frequently showed great homing instinct, and, when ridden long distances round about. would sometimes escape homeward in the night-time, always going in a direct line—I refer to the extensive Canterbury Plain, where the only obstacles were the swift-running rivers.

I remember starting from Christchurch in 1856, driving a two-horse dray (heavily laden), crossing the Waimakariri River, and making for the Oxford district. In the evening, when actually within sight of my destination, a thick mist came on, and I was only able to see ahead the length of my team. After proceeding some distance I became doubtful as to my position, the more so on account of my passing many toi-toi bushes—a tall grass (*Arundo conspicua*) resembling the pampas grass. Feeling convinced that something was wrong, on my next arriving at a toi-toi I broke down several of its tall seed-heads and drove on, and coming once more to a toi-toi bush and examining it in the dim light of departing day I again beheld the broken seed-stalks. On starting again the same thing took place. Finding from this that I was moving in a circle, I gave a "coo-ee," and to my delight received an immediate answer, and at once started towards the sound, but I had not gone far before the call was repeated immediately behind me. This same thing occurred several times, and I determined to remain stationary, replying occasionally. Presently up came my elder brother (whom two days before I had left in Christchurch) on horseback. He said, "Where is the house, and what are you doing here?" when a call was heard, and my younger brother joined us, he having left the house to come to the rescue. My younger brother persisted that we were on the wrong side of the river-course (then a dry bed of shingle), but this I denied, as it was impossible to drive a dray over shingle without being aware of the fact. It was ultimately decided to take off the leading cart-mare, whose foal was following, and presumably occupying her attention, and trust to the shafter drawing the load in a homeward direction, although the darkness of night was now added to the confusing mist. This proved a success, and we soon arrived at home.

One day when herding sheep a dense snowstorm came on, and I left the flock and made for home, but soon found sheep in front of me, which proved to be those I had left. The same thing resulted several times, when, taking a wider bend, I came to a mob of horses, and decided to follow and drive them till they took me home. This plan succeeded admirably.

I have known horses to be snowed up in a mountain valley to a depth of 2 ft., with over 7 ft. in the drifts, and the river

frozen over and buried in snow; yet they kept in good condition for two months, scarcely moving, but pawing away the snow until coming to the 2 ft. length of snow-grass (*Danthonia*, sp.?), on which they fed. They seemingly required no water; certainly none was procurable during that time. And these horses had been brought from the north, and therefore had no previous knowledge of deep snow and the grass to be found beneath.

I was lately told by a reliable person of an old and favourite horse who was able to open all the gates, and the remedy found effective in stopping him was hanging bits of tin to the gate. He would stand blinking his eyes and shaking his head, but was completely checked by this simple device.

Mares will travel at times long distances to the place where they have received service of the horse, even to going through the centre of a considerable town and remaining pawing and forcing open the stable-door within which was their wished-for mate.

When I was a small boy in England we had a thoroughbred pony and a donkey kept in the same paddock, and one day I noticed quite a small crowd of persons standing in the roadway intently looking at something. The pony was carrying a large stick in his mouth, and was seemingly striking and poking the donkey to make him gallop around. The explanation of this would probably be found in the mischievous habits of the pony; it would sometimes run away with our jackets when laid on the grass whilst we were engaged in a game at cricket. This pony (Fireaway) was certainly very intelligent, and distinguished himself greatly when following the Rufford foxhounds, being very swift and a remarkable fencer.

A fierce duel between mares, when carried on with proper science, is very interesting. To present as small a point of danger to themselves as possible, each runs back so as to keep as near the other as possible, and thus prevent a lashing-out kick. To save their hind legs, as it were, they almost sit down on their tails, looking backward with head turned over the shoulder, squealing shrilly all the time, and jumping about in this singular attitude with great activity, and watching to catch the other at a disadvantage. I have only once seen this encounter in a lifetime.

I once saw two stallions fighting. They upreared themselves frequently, so as to seem surprisingly tall, actually wrestling, as it were, and biting each other on the crest of the neck and withers. Their stertorous breathing could be heard a long distance off. This fight between Jersey and an old cart-entire came off on a clear moonlight night, and roused me from a sound sleep. I rushed away with a long stock-whip and drove the two, still fighting madly, notwithstanding

my heavy cuts with the whip, backward through the gate of the stockyards, where I ultimately placed them on either side of the fence, and closed in; but Jersey jumped the tall fence and made off to his mob. There was thus no knowing what the final result of the fight would have been.

I knew a mare who would eat cooked meat, and on coming to a new place would always walk round and look for the pig's swill-tub, drinking the sour contents with great relish. One of our party once made a sea-pie for Sunday's dinner and placed it at the door of the house to cool, when this mare, happening to see it, ate it up. She probably had been hand-reared, but was four years old when I first made her acquaintance. She was afterwards sold to Mr. Freeman R. Jackson.

The horse bot-fly (*Œstrus*, sp.) has been brought to this country, and is becoming a great plague. Striking the horse chiefly about the forearm and under the chin, while on the wing it darts forward, and, by aid of its ovipositor, leaves an egg attached to the hair of the horse each time it stings (as the vulgar term describes this action). In Otago it is reported that horses at times die through the numerous bot-grubs piercing the walls of the stomach.

The Ox.

In using the term "ox" as the heading to this paragraph I but follow the original usage, although we of the present time would more readily accept the word "cattle." Formerly the bull and cow were spoken of as "large cattle," and the sheep and goat as "small cattle"; for "cattle" and "chattel" were originally the one word, as denoting the property or wealth of the individual. Where cattle have the range of a large area of land, and the human inhabitants thereof are few, they readily relapse into a feral condition. Instances of domestic cattle becoming thoroughly feral have repeatedly occurred in many parts of New Zealand.

In the early "fifties" I remember hearing of a strong party of stockmen attempting to capture a considerable herd which were located to the north of the Ashley River, in Canterbury. One lot of these wild cattle was surprised on a moonlight night and forced from their usual haunts; but on arriving on the sea-beach they all took to the water as if crossing a river, and, swimming out to sea, were never heard of again.

In 1859 my brother John, myself, and a hired man drove nearly three hundred head of cattle from the neighbourhood of Christchurch through Otago to the south side of Lake Wakatipu—a considerable undertaking in those days, for we had to swim the Waitaki, Molyneux, and other rivers, and roads there were none. In the early morning, when breaking

camp on the Saddle Hill Range, near Dunedin, we, as was our custom, let the riding-horses and pack-horse go among the cattle, to save them for the more severe work of returning after any beast which might stray on the back-track during the night, and because, our rate of travelling being slow, we were as well on foot. There was snow on the ground, and during the day we passed a miniature snow-hut, where lately a man and woman, having their horses bogged, had managed to exist through a stormy night. In fact, some person had lately found the lady's horse (presumably dead), and placed the side-saddle on a cairn of stones, with a paper attached asking that we take it on to the first house at the foot of Saddle Hill. Many cairns of stones were erected to direct the traveller round the bogs, but in our own case we omitted to notice a cairn at an angle, and, making a straight line to the cairn beyond, went into the morass, and lost some hours extricating the pack-horse, &c.

But to return to my proper subject. The three of us commenced to collect the cattle and drive them forward, we being on foot, when one of us was chased some distance by a wild cow that had become separated from her calf. This cow returning to the herd, we got the cattle moving in the right direction, but soon were chased by other cows, I having to flee to a cairn of stones in great fear and haste. It became evident that about twenty wild cows and a large wild bull had got into our mob. Being unable to get our riding-horses from amongst the cattle on account of these fierce cows, we seemed to have quite lost command of the situation. Presently the bull galloped down the sloping ground towards the forest (possibly above Blueskin), followed by the other wild animals, and with some twenty of our biggest steers following madly after. I was, as you may suppose, transfixed with horror at the sight, but started my sheep-dog Maori after them, and he actually ran in behind the wild cattle and luckily succeeded in checking the leaders of our mob till we came to his assistance. This action of the dog surely showed his great sagacity, and is well worthy of record.

In the great forest extending, till lately, some seventy miles in unbroken line on the south of Hawke's Bay and northern part of the Wellington Province many wild cattle have been killed, and noting those which I have seen, which resembled shorthorn cattle, it was evident that many showed the inclination to breed a black colour. I saw among ordinary colours some black-and-white cows, and dark-red-brown and brindled bulls—one cow a beautiful light-yellow and white patches. On questioning others who have hunted these cattle, they all agree that they incline to a darker or black colour among individuals of those seen. These cattle

feed on the leaves of certain small trees and shrubs, and have the peculiar habit of forcing even those about 7 in. in diameter at the butt to the ground by use of their horns, but more especially by breasting them down. At one place I noticed several acres of an area having every small tree laid over and mostly on the ground, this being all done by wild bulls breasting them down.

Tame cattle escaping to the forest at once become exceedingly timid and cunning. At one time in Otago I lost for some time a pair of barren cows which were leaders in my team of working bullocks, and could not find them high or low; but one day, when looking across the mountain valley (some mile in width), something curious was noticed below a tree at the edge of a small birch forest (*Fagus*, sp.), which on examination with a glass proved to be the face of Chloe, the smaller of the two cows. The face was then withdrawn and seen no more, but on going to this place next day I saw evidence that the two cows had been in hiding actually within a mile of my house, but being cunning, and remaining among the trees, never coming out on the grass land, except possibly after dark, had remained undiscovered.

The deep-voiced bellowing of a wild bull in the forest is something quite tragic, the *boo'a, boo'a, bo,* sometimes beginning in deep bass and ending in a shrill trumpet-sound. With three companions I was once travelling through the forest when we heard these deep resounding calls, giving the information that an old bull on the war-path was ascending the sloping hillside and approaching our position. The younger of the party, whose turn it was for next shot, carried the carbine, and so was expected to keep valiantly to the front. I myself was bringing up the rear, and must confess that as these deep roarings came nearer, and seemed to vibrate along the ground from no particular direction, the idea of seeking a safe harbour became predominant, so, rushing off to a large rata-tree, and then peeping from behind the tree-butt to see how the battle waged, I was surprised to see nothing of my two friends, whilst the third was seen hanging to the bough of a tree, and the carbine had fallen to the ground. One of the others (a surveyor) ran for the carbine, and took a hurried shot, causing the bull to retreat hurriedly, without my seeing what sort of an animal he was.

One can well suppose on hearing such sounds that the name "bull" is compounded of *bo*, the call or sound, and the root-word of Latin *ul-are*, to howl—as we also see in Latin *ul, ul, a,* an owl; also in our words *howl* and *owl*—vulgar English, *ullet*, the screech-owl. The bellowing of some dozen steers or young oxen, heard at midnight when trampling round and pawing up the earth about a bullock-hide which

was pegged out to dry, once gave me a start; the united concert was truly diabolical.

Cattle will also congregate about a spot where blood has been spilt, or an animal killed, becoming quite mad in actions and bellowings; they are also dangerous to the wounded of their own kind, or to cows when calving. A cow with freedom to roam will, when calving, wander to a distance, and then hide the young calf in some concealment, herself feeding apart, but coming at times slyly to attend to the calf. It is not exactly safe for any person to come accidentally on this hiding-place.

Where domestic cattle are allowed to roam in large herds the bulls for a part of the year will leave the herd, and then three or more bulls may be found amicably associated together, notwithstanding their deadly hatred of each other at other seasons. This habit of the males becoming a bachelor party is also common to the sheep and goat, and may be taken as a good instance or proof that all three animals are descended from the same far-away ancestors. In fighting bulls decide a battle mainly by pushing with their heads locked together, rather than by goring with the horn; yet the vanquished when in flight may receive stabs if too exhausted to make a speedy retreat. I once saw the hunted bull run into at a right angle, lifted completely off his feet, and hurled down a steep terrace, which terrace had prevented his escape in a direct line.

Old bulls kept in paddocks (fields) often become very expert in lifting gates from their hinges when they wish to roam about. I had three generations of white bulls, all of whom learned this trick in their third year, when I used them in the bullock team as "polers," and so gave them more travelling than they desired. This would seem an instance of inherited instinct.

About the year 1860, when I was living near the head-waters of the Oreti, or New River, and the surrounding country was as yet unknown to the pioneer settler or surveyor, Messrs. David McKellar and Gunn, neighbouring sheep-farmers, came to my log-and-thatched dwelling and stayed the night with me. They proposed to endeavour to find a way through or over the mountains westward to Martin's Bay, between the Mavora Lakes and head-waters of the Greenstone River. As I had already found a way to the northern end of the Mavora Valley, I agreed to pilot them thus far, wishing to explore the valley in search of stray cattle. These gentlemen did not reach the West Coast, but their journey is recorded in our maps by the names of Lake McKellar and Lake Gunn. We camped the first night at the head of Mavora Valley, near a small lagoon. The following

morning we separated, I following down the valley in the direction of the lakes, where I found about fifteen head of mixed cattle and one small calf. These I captured, and journeyed on along the west side of the lakes, and presently found the steep hillsides covered with "wild Irishman" (Maori, *tamatakoura*) and thick layers of dead grasses, the accumulation of many years, for the white man's fire had not yet roared along the mountain-side. A narrow belt of small shingle by the edge of the lake gave me a fair road till well along the side of the second or lower lake, when I noticed a single birch-tree (beach) branching low over the water, and also that the cattle, on going further out to get beyond the lower branch, were swimming, having gone over the edge of a sunken terrace into deep water. (This sudden deepening of the lake in terraces is a common peculiarity of most New Zealand lakes.) Thinking that with great care I might steer my horse round the tree without slipping into deep water, I followed on, but soon had my horse swimming, and he would persist in going under the bough, which then came directly across my chest. Hanging on by one hand to the saddle I kept the horse from progressing, but was unable to turn him outward beyond the bough. Finding my efforts fruitless, the only alternative was for me to turn a half-somersault over his tail, and sink to the bottom, some 10 ft. On coming up I followed my horse under the bough, and went along some distance further, where the precipitous rocks of the mountains reached out to the deep water. Seeing this I sent my dog Maori to turn the cattle back, keeping out of the way myself by standing among the prickly shrubs; but instead of turning back the cattle swam out into the lake, where I at once lost sight of their bobbing heads, for it was now the dusk of the evening. For a time their hard breathing was heard, and then no sound. After a while they were heard again, and I congratulated myself, thinking they were swimming ashore again; but no, all again were lost to hearing, and, as it was now almost dark, I felt considerably dejected, thinking of my drowning cattle. This, if I am not mistaken, was in the month of May, and as the nights were liable to be frosty I did not know how I should pass the night. My matches were wet, as also my clothing and my one blanket. No food, no fire. Collecting a large heap of the grass that was lying around as it had died—perhaps years ago, for the living grass grew in a straggling way up through this hay-like substance—I took off my wet clothing, and with some excusable shrinking put on my waterproof overcoat and crawled under the pigs' bed of dead grass. In the morning frost was on my clothing, so I waited for the sun to warm things up a bit before donning the wet

clothes. I had a look across the lake—a distance of probably a mile—and could faintly discern cattle feeding on the hillside. How I followed my horse, carrying the saddle on my own back, until he was caught by my making a short cut across a promontory, and travelled round the lake, reaching the cattle about midday, and found my way through the belt of birch forest, reaching home that night, are memories of the past. These cattle were the same fifteen head, and even the calf was with them. This I should say is a record swim, taking into consideration that it was undertaken in the dim gloaming, and that the course could hardly have been a direct one under the circumstances.

The Sheep.

The nature of the merino is very feral. They prefer the high mountain-range. When alarmed a blowing whistle is made through the nostrils, and the instinct is to make upwards. They also stamp with the fore foot. In mustering large flocks they are driven along the mountain-range by shepherds walking a distance apart, so making a line from top to bottom of the hill, and forcing the sheep in one direction for three to nine miles, thus massing them up to a suitable place to force them on the lower flats or valley-bottom, from whence they are driven to the yards.

Sometimes very large losses occur even in careful management, and when no person is within a considerable distance of the animals, who are "stringing" along in long lines, looking from a distance like many long snakes wriggling along the face of the hill. This may be called "the follow-my-leader instinct." If the first sheep in a string should enter a creek-hollow at the wrong place, and be unable to climb the opposite side, those following may keep coming on and tread underfoot their leaders, who may be all smothered, and make a dying bridge for the remainder to pass over. It is a difficult matter to stop those following when the danger is observed, for even two or three men may not at first be able to "break the string" and direct those following into a safer course.

Rams, when the season is off, will collect together in parties of three to fifteen, and many, if fences allow, will come to the gate of the ram-paddock as to their proper home.

If black sheep are bred together their progeny is also black, or grey. The merino gives the more uniform black, often with forehead and tail white. I have a flock of eight hundred old sheep and some two hundred and fifty lambs, crossbred merino-Lincoln. Having started this flock eleven years ago, my returns for wool are below the average for white fleece. Many of these sheep have a small white spot under either eye, and in light-coloured ones the belly and thighs are

darker than other parts of the body, which I term the "water mark," as though the animal had crossed a shallow stream. To what form of wild ovis do these peculiarities show an affinity?

Œstrus ovis, or sheep bot-fly, has been imported with the sheep. The young grub enters and climbs the nasal passage, and can follow an opening which leads to the horn-core of the merino. I have found as many as eight well-grown grubs in one horn. This connection from the horn to the nostril is seen on the breaking off a horn by accident, when the observer may notice that when the sheep coughs the blood on the head will be sprayed about by escaping wind.

The new-born lamb will follow its mother, and does not "plant."

THE GOAT.

The goat is naturally wilder than most breeds of sheep, but when made a pet of is more of a companion than a sheep would be. Their note of alarm is, I think, made through the nose, but has a thick-lipped sound: the nearest I can write it is "purrup."

The kid is hidden away, and the mother comes to it at long intervals. Even when well grown and following in the flock the kid is liable to "plant" or bolt away for hiding when the flock is mustered. They will even lay in hiding with closed eyes, the more readily to escape detection.

Goats when handled mostly cry out; they are not like sheep, "dumb before her shearers." Angora goats shed or cast their wool so soon as the spring grass is eaten, the wool becoming matted and peeling off, which is a considerable drawback. It is remarkable to see that they strip the bark from some trees higher than 8 ft. from the ground, and also will bend a tall thin stem having foliage beyond their reach by taking the butt in their mouth and bending it over, continuing to pass the mouth along towards its extremity until the top is reached, which they cut off by the back teeth as if by a pair of scissors.

They soon become accustomed to be fastened by a tether-line, but, like all animals with which I have had experience, they wind their rope around the tether-peg. They require a swivel on the rope, otherwise by always going round the same way they unlay the strands of the rope. Why animals always persist in making the circle in one direction only, and never or rarely go in an opposite direction, is truly remarkable. This habit will cause a tethered animal to starve to death if not constantly attended to, for it will become wound up short by the neck or head. Why is this? Can it be because of right- or left-leggedness, as the leading off with one particular leg?

A circus-horse would require to lead with the outer fore-leg—that is, the leg further from the centre of the circle. In going the reverse way about the leading leg would require changing, but this mode of action more especially depends on cantering or galloping. I recommend the study of this theme to those who have time and methodical patience. If you take a dog, and fasten him to a stake a small distance from his kennel, allowing him room to get round it, you will soon see him wound short up and crying because he is unable to enter the kennel. He never by any chance sees the necessity of walking round the stake the opposite way, but will remain so shortened up until he dies, although food and water may be only the length of the chain away. Notice the chain is fitted with a swivel, and why? Because we know by experience (without understanding) that the dog will actually "go around himself," and so, if there be no swivel, knot the chain short up. He never by any chance will turn the opposite way, and so take the turns out of the chain and benefit by its full length.

I have, unfortunately, never taken special note as to whether, say, one goat may go right about and another left about, or must they all go round the same way as the sun, as we are told to stir the pudding in the making.

After the manner of the rams and bulls, the buck goats associate together for half the year. This inherited instinct no doubt descends to them along the branches of the same ancestral tree.

I have no evidence of the goat suffering from *Œstrus* grubs, but have noticed them fight the fly by stamping on it, and by the goat rubbing its nose along the ground as if to clear away the insect or its eggs.

Art. XXXIII.—*Maori Spirals and Sun-worship.*

By Edward Tregear.

[*Read before the Wellington Philosophical Society, 11th July, 1899.*]

Plates XXII.-XXIV.

In calling attention to the subject of sun-worship, the great difficulty that arises is not from want of material, but from the vast array of expert evidence, and the enormous range over which the erudition of modern scholars inquiring in this direction has extended. In one branch of the inquiry alone—viz., the meaning of the *swastika* cross—a huge pile of books and pamphlets has accumulated, and to wade through all the

examples, the statements, and the speculations would entail very prolonged study, and need a diligent as well as a clear brain to escape utter confusion of memory. The process, however, even if nothing else came of it, would be very useful to those who, living in a narrow little world of their own interests, have no idea of the great rivers of thought that, unknown to them, are in far-off and little-known places bearing day and night their tribute to the ocean of human knowledge. Only one of these rivers—nay, a stream—can be approached in this paper, but my writing may tend to show not only how little I know, but also how little any other man knows about things close to us and regarded as common and devoid of interest.

My paper will therefore be contracted into such an inquiry into sun-worship as may be conducted along lines pointed out by the *swastika* cross. Although this sign may be only one of the numerous symbols used in the ancient world, it has this royal pre-eminence: that it is at once the oldest and the most widely spread of all such characters. I have alluded to the large bibliography that would contain the names of all books dealing with this cross, and I will try not to weary with long quotations or too many references. I may briefly state that it was known almost universally in the ancient world under some of its many forms. In seven-times-buried Troy, in Egypt, Greece, Scandinavia, Great Britain, France, Italy, Russia, India, China, Korea, Japan, and the Americas, over three-fifths of the inhabited earth's surface the *swastika* is found in evidence. This curious symbol in its square shape is formed like a Greek cross with a bent arm at each angle, the bends all being made in the same direction. It has many variants, and it is in one of its variants that I shall try to trace its presence in New Zealand. I diverge for a moment by premising that nothing in this paper has anything to do with the use of the cross in the Christian religion. Those who are so ignorant of archæology and ethnology as not to know that the cross was used by great peoples ages before the Christian era need not proceed further, but must begin elsewhere at the ABC of antiquarian research.

Of course, there are many persons whose theories on the subject refuse to admit that the *swastika* has anything to do with the sun or sun-worship. This denial may be true if the subject is only studied in its modern or comparatively modern phase. There may be nothing in the *swastika* as employed to-day by Buddhists or Brahmins to show connection on their part with sun-worship; but we have to deal with the study of origins, and try to find out what was the early meaning of the sign. Some writers, for instance, insist that the *swastika* was a representation of the Aryan fire-drill,

whereby fire was made by the friction of wood, the drill working vertically on the centre of the flat cross, which was held down at its angles. I believe this to be true, but it was only a later and subsidiary use of the sign—nay, probably the fire-drill itself was purposely made in the shape of the *swastika*, because fire is the child of the great solar fire-giver. Others think that the *swastika* cross, like the *tau* cross and the *ankh* cross of the Egyptians, was a symbol of reproduction and generation. This also may be true as a late phase, if we consider the ideas associated with the production of fire by friction of wood among all barbaric and therefore poetic peoples. It is unnecessary to detail or attempt here to refute the many theories; it will be sufficient to briefly state what a few writers of authority have stated as to the connection between the *swastika* and sun-worship. R. P. Greg* says that the *swastika* was adopted as a solar symbol in Greece, and converted later, about B.C. 650, into the meander or key pattern. Professor Goodyear† writes, "The solar significance of the *swastika* is proven by the Hindu coins of the Jains." He adds that it is an equivalent of the Egyptian lotus and of the spiral scroll and the Greek key pattern. Birdwood‡ states, "I believe the *swastika* to be the origin of the key-pattern ornament of Greek and Chinese decorative art." Without further quotation, I may affirm that such authorities as Count Goblet d'Alviella, Ludwig Müller, Percy Gardner, S. Beal, Edward Thomas, Professor F. Max Müller, H. Gardoz, and Dr. Max Ohnefalsch-Richter, all admit that the *swastika* is a symbol of the sun or sun-worship. Even the sun-worshippers among the North American Indians wear the *swastikas* on their ceremonial dress, and these signs appear on the mythological charts drawn on the floors of the Sun-lodge.§

I think, then, that with the opinion of these authorities in its favour we may very well consider the primary connection of sun and *swastika* as a fairly tenable hypothesis. A far more certain and positive statement, borne out by evidence obtained among men who use the *swastika* to-day, is that it was used for centuries, and is still considered a sign of "good luck." Professor Max Müller, the profound Orientalist, says that the word "*swastika*" bears the meaning of "an auspicious mark." "In the footprints of Buddha the Buddhists recognise no less than sixty-five auspicious signs, the first of them being the *swastika*."||

* "Archæologia," xlvii., pt. i., p. 159.
† "The Grammar of the Lotus," p. 354.
‡ "Industrial Arts of India," p. 107.
§ Smithsonian Report, 1894, p. 895.
|| Professor Max Müller in his contribution to Dr. Schliemann's "Ilios," pp. 347, 348.

The "Cyclopædia of India," dealing with the subject of the *swastika*, adds that the etymology of the word means "Be it well!" and with this General Cunningham* agrees. Professor Monier Williams, in his Sanscrit dictionary, says that *svastika* is "a kind of mystical mark made on persons or things to denote good luck," and derives it from *svasti*, "welfare, blessing." Burnouf writes,† "It was used among the Brahmins from all antiquity. *Swastika*, or *swasta*, in India corresponds to "benediction" among Christians. The same author, in the "Lotus de la Bonne Loi" (Appendix), says, "The sign of the *swastika* was not less known to the Brahmins than to the Buddhists. Most of the inscriptions on the Buddhist caverns in western India are either preceded or followed by the holy (*sacramentelle*) sign of the *swastika*." Mr. W. Crooke‡ writes, "The mystical emblem of the *swastika*, which appears to represent the sun in its journey through the heavens, is of constant occurrence. The trader paints it on the fly-leaf of his ledger; he who has young children or animals liable to the evil eye makes a representation of it on the wall beside his door-post. It holds first place among the lucky marks of the Jains," &c.

The *swastika* sign is used as one of the pictograms of the Chinese, and means "long life," "many years"; but this was probably not the original signification, as the Empress Wu of the Tang Dynasty (684–704 A.D) decreed that the sign for the sun should be a *swastika* in a circle. This is the statement of the Chinese Minister Yang Yu to Mr. Wilson, but it is confirmed by Professor G. F. Wright. To leave the East and go to Great Britain, where we should hardly expect to find it in use, I will quote Mr. J. B. Waring,§ who says, "It may be seen upon the bells of many of our parish churches, as at Appleby, Maxborough, Hathersaye, Waddington, Bishop's Norton, West Barkwith, and other places, where it was placed as a magical sign to subdue the vicious spirit of the tempest." In the discussion before the International Congress of Anthropology and Prehistoric Archæology, 1876, the report of proceedings says, "It seems to have been agreed that the sign (*swastika*) stood for blessing or good luck," this relating to runes on an ancient Scandinavian bronze sword. So it appears that it stood for "good luck" even in the age of bronze, a far cry back. Miss Mary Owen, writing concerning ceremonial garters, &c., worn in sun-worship by North

* "Bilsa Topes," p. 17.

† "Des Sciences et Religion," p. 256.

‡ "Introduction to Popular Religion and Folk-lore of Northern India," p. 58.

§ "Ceramic Art in Remote Ages," p. 13.

American Indians—Iowas, Kickapoos, and other tribes*—states, "The Indians call the *swastika* the 'luck,' or the 'good luck.' It is only to be found in beadwork of a kind not now available."

I think that we may take these records of ancient and modern signification of "good luck" as fair proof that the symbol was used to ward off misfortune and bring safety to those using it. So much for the signification, now for illustration of the evolution and development of the elbowed cross.

Its simple form is that of a cross (fig. 1), but its birth took place probably in the circle. Mr. Edward Thomas† writes, "The earliest phase of astronomical science we are at present in position to refer to, with the still extant aid of indigenous diagrams, is the Chaldean. The representation of the sun in this system commences with a simple ring or outline circle, which is speedily advanced toward the impression of onward revolving motion by the insertion of a cross, or four wheel-like spokes, within the circumference of the normal ring." In figs. 2, 3, and 4 we have this advancing representation, showing the cross *swastika* on the circular sun. In fig. 5 we have a variant cross—a *swastika* with spirals; and in fig. 6 the circle is lost, while the curved cross remains. Fig. 7 is another form of the square cross. And here I will draw attention to a point I must further refer to afterwards—viz., the great difficulty of drawing the *swastika*, whether in curves or squares, if the idea of circular motion is to be kept. If any one doubts this let him try to draw fig. 7 accurately with a freehand style. The next figure (fig. 8) shows the Greek keyboard or meander, but it is the double pattern, the Egyptian, and not the plain Greek. You will notice how the intricate *swastika* crossing lives in this border. We could be hardly certain that the *swastika* had anything to do with the plain Greek border if it were not for a beautiful example found on a Greek vase where the simple keyboard reverts at the end of the band into the *swastika* itself (fig. 9). I have given above instances of the square cross passing into the spiral, and in the next figure (fig. 10) we have a very beautiful illustration of the *swastika* spirals at their best. It is given by Professor Goodyear, who leads up to it, indeed, by a different path, for he evolves the *swastika* from the spirals of the lotus, which was a flower sacred to the sun and to solar worship. However, in regard to this ornament on an ancient tomb in Thebes, the professor states directly that this is a *swastika* cross, and that the central ornament is a lotus-flower, an emblem of the sun. The last illustration of the

* Smithsonian Report, 1894, p. 895.
† "History of Art in Chaldea and Assyria," p. 200.

kind (fig. 11) is the representation of a pottery vase found in Arkansas, United States, in an ancient burial-mound. You will see very distinctly how the four arms of the cross make the double volute, precisely as in the bow-piece of the Maori war-canoe. If the Maori spirals are not *swastika*, then the figure on the vase is not a *swastika*, and yet experts distinctly state that the latter is a form of the famous cross.

I do not for a moment contend that the ordinary spiral must necessarily always be a sun-symbol. Such a figure is so easily made, and so easily imitated, that it might become a pattern of barbaric decoration without any religious or mystical meaning in the mind of the artist. The cup-markings which are so widely known, and the concentric circles to be found on the *churinga*, the soul-sticks of the Australian blacks, are instances in point. They may be symbols of the sun or of a dozen other things; they are so easily made and so ornamental that the mind must be of extreme simplicity that can not only imitate but originate such marks. Conceive, for instance, a savage picking up a forked branch and idly sticking one end of the fork in the ground or in the ashes; he moves the point of the other arm round in a ring, describing a circle. Squeezing the fork slightly, he makes a concentric circle inside the first, and so on. The wonder would be that if it was done once it should not be done again often. The same rule holds good for the spiral. Any one who has rolled up a slip of paper or a ribbon from its end and then lets it go knows how it uncurls in a spiral form, and a savage who did the same with a long flexible leaf or a thin strip of pliant bark would immediately see its value for decoration if he had the slightest taste for carving or painting. Granting, then, that the spiral ornament might have originated independently in a hundred places, that it is not difficult to copy, and that it might symbolize a thousand things, is the same true of the double spiral? Not by any means. The double spiral is not only unlikely to be often invented, but it is an exceedingly difficult figure to draw. Now that I have tried to draw some of them true to scale I am filled with admiration of a native carver who, without my drawing instruments and books of logarithms, can describe such pure and perfect curves. As any mathematician would tell you, a man who could calculate and lay out the lines of the double spiral is one whose knowledge of figures is above the average. Of course, the Maoris had no such knowledge, but their best carvers must have not only had great aptitude for their work, sometimes amounting almost to genius, but they must also have had long and careful training before the eye could fix and the hand delineate these flowing volutes. Such a figure, so difficult and so invariable in its position as a bow ornament, would never have been

chosen and never have been executed without some strong overmastering motive for the design. If the Maori executed with infinite trouble the double spiral of the sun-worshipper, does there not seem to be exceeding probability that he shared the ancient knowledge of the sun-symbol known on every continent of the Old and New Worlds? Another proof of this, though a slight one, is that in the perfect bow-piece under the spirals lies as a support a conventional human figure, stated by the Maoris to be an image of Maui. Maui, the Polynesian hero, was undoubtedly a sun-god; that has been proven and accepted by scholars. The moon (Hina) was his sister, and, like Prometheus, he was the fire-bringer.

Having seen, then, that spirals are connected with the *swastika*, with a primitive reference to the revolving sun and a later meaning of "good luck," is there any proof in New Zealand itself that the Maoris were ever sun-worshippers? It would be of little use to show that the natives were in possession of a sun-symbol unless we could learn that it was highly probable that their forefathers knew the meaning of it. The Maoris (or some tribes of them) certainly worshipped the sun. The early missionaries knew little on the subject of the Maori religion, and unintentionally misrepresented the beliefs in the native mind as to the dwellers on Olympus. Inquirers of a different type took up investigation, and to men like Sir George Grey, Mr. John White, Dr. Shortland, Canon Stack, Elsdon Best, S. Percy Smith, and others new light on dark places was revealed. The Polynesian Society in its eight years of existence has also done much to let us understand the spiritual attitude of the ancient Polynesians, and I trust that it will do more.

The author of "The New-Zealanders"* (printed 1830) quotes from Savage in his "Account of New Zealand," who says, "When paying their adoration to the rising sun the arms are spread and the head bowed, with the appearance of much joy in their countenances, accompanied with a degree of elegant and reverential solemnity, and the song used on the occasion is cheerful." The author remarks that it is strange that none of their other visitors have remarked this species of idolatry among these savages, but adds, "Yet two New-Zealanders who are now in this country (England) were in the habit of commencing the exhibition of their national customs with the ceremonies practised in their morning devotion to the sun." This evidence has been ignored, probably because unconfirmed by others not making particular inquiries in this direction, but weight should be given to it as the observation of an exceedingly early visitor to New Zealand, who, if not as

* "Library of Entertaining Knowledge," p. 232.

good a Maori scholar as those who came after, had the advantage of seeing the natives in a far more primitive state than we can, and knew quite enough of the language to understand whether the Maoris said that they were worshipping the sun or not. It is probable that the practice lingered only among certain tribes, thus the Rev. Mr. Taylor spoke of the worship of the heavenly bodies as being practised at Whanganui,* whilst Mr. John White's legendary account belongs to the South Island. Mr. White, in his "Ancient History of the Maori,"† writes, "Then they selected a hundred and seventy men of their tribe and went to the home of Hapopo, and, having found Niwa-reka there almost alone, one of the party asked, while all the others were silent, 'Where are the people?' She answered, 'They are yonder, out on the plain.' He asked, 'What are they doing?' She answered, 'They are chanting songs and offering sacrifice to Ra (the sun).' He asked, 'For what purpose?' She answered, 'To suppress the ill-feeling of the people, and to give quiet to the land.'"

The Sun Feast, or Te Hakari, was held annually, and there is a number of perpendicular stones resembling Druidical remains still known by this name (or as Waka-ra) between Kerikeri and Kaitaia.‡ Indeed, it would appear strange if sun-worship, known to exist among other Polynesians, had been unknown to the Maoris. The Easter-Islanders worshipped the sun,§ and the Polynesian colony at Port Moresby, in New Guinea, did so also.|| At Mangaia Island, near Rarotonga, they speak of Tevake, who "worshipped the red light in the east,"¶ and in Samoa they not only worshipped the sun, but offered up a human sacrifice to that deity every day for eighty days.** Therefore it is probable that if the Maoris used a sun-symbol they did so with a full knowledge (*i.e.*, ancestral knowledge) of its meaning.

NOTE.—To my deep regret I have here to suppress a part of the paper as read. It described the sun-lodge, &c., in New Zealand, and had a most important bearing on the rest of the monograph. The Maori scholar, however, to whose learning and zeal for investigation my knowledge on the subject was owing, considers that its premature publication would be unfair, and that it would detract from the interest of a work by himself in which he treats upon the subject. Therefore I withdraw this portion of the paper, and can only look forward with other lovers of native lore till Mr. C. Nelson gives us the advantage of his studies in his forthcoming book.—E. T.

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* "Te Ika a Maui," p. 99.
† Vol. ii., p. 53.
‡ White, "Maori Superstitions," 108.
§ "Journal Anthropological Society," ii., 190.
|| "Pioneering in New Guinea," Chalmers, p. 171.
¶ W. Wyatt Gill, "Savage Life in Polynesia," p. 31.
** Turner's "Samoa a Hundred Years Ago," p. 201.

There have been few attempts hitherto made to explain the meaning of the war-canoe spirals. One writer* says that he was informed by an old Maori that it (the spiral) was copied from the uncurling frond of the mamaku tree-fern. A young frond of this kind is called "pitau," and so are the canoe spirals in some places. I am inclined to think that the process has been reversed, because "pitau" in its best-known sense means not only the bow-piece, but the whole war-canoe itself—that is, if such war-canoe has a figure-head with a body and arms. Again, the fern-frond is a single spiral, while the carved bow-piece is a double spiral. The skin-mark on the thumb has also been suggested, but I do not know if from any authority.

I have stated in my Maori-Polynesian Comparative Dictionary that the coils of the war-canoe bow-piece were signs or representations of Winiwini, the god of the cobweb. This I did on the personal authority of Mr. John White, author of "The Ancient History of the Maori," and an erudite Maori scholar, who assured me that this was the fact. If this was so, it is a strong confirmation of the *swastika* theory, for it was most probable that Winiwini was a *swastika* cobweb like that drawn by the Chinese as a sign of "good luck." I present a copy of the Chinese picture (fig. 13), not that it is like a real cobweb, but as a painting of a "good-luck" sign. Whether any spider ever made such a web is exceedingly doubtful, and we must take the account given by the Chinese with a grain of salt, but they relate as follows: "Fung Tse, of the Tang Dynasty, records a practice among the people of Loh-yang to endeavour on the 7th of the seventh month of each year to obtain spiders to weave the *swastika* on their web. Kung-Ping-Chung, of the Sung Dynasty, says that the people of Loh-yang believe it to be good luck to find the *swastika* woven by spiders over fruits or melons."† Not only did the Chinese have this fancy, but it pervaded Indo-European mythology. De Gubernatis, in his "Zoological Mythology,"‡ states that the evening and morning aurora are compared to the spider and the spider's web. "If the sun dies without clouds, if the luminous spider shows itself in the western sky, it augurs for the morrow a fine morning and a fine day." Here, then, we see for the first time why the solar emblem should have been turned into a sign of "good luck." It was when the "luminous spider," the sun without clouds, augured good luck for the morrow. To notice how very ancient the idea is you have only to turn to the Rig-Veda,

* Hamilton, "Maori Art," pt. i., p. 11, note.
† Smithsonian Report, 1894, p. 800.
‡ Vol. ii., 162.

the sacred book of the Brahmins, and you will find that the Aurora weaved during the night the robe of her husband, the Sun. One Vedic hymn advises the Aurora not to stretch out her web too far lest it get burnt,* and the Dawn is described as adorning herself for her husband, the Sun, with a display of luminous garments.† The Greeks carried on the myth under the form of Arachne, the weaver who was transformed into a spider, but Arachne is only a variant of Aurora. The cobweb has become a symbol of dawn because in the early morning it has such beauty. Keightley‡ says, "Every lover of nature must have observed and admired the beautiful appearance of the gossamers in the early morning, when covered with dew-drops, which, like prisms, separate the rays of light and shoot the red, blue, yellow, and other colours of the spectrum in brilliant confusion."

Finally, I would call attention to the antiquity in which this "good-luck" symbol was applied to ships. Bharata is the hero of India after whom the land was called, and after whom the native speaks of it to this hour, as "the Land of Bharata"—*i.e.*, India. In the great poem of the Ramayana that recounts the deeds of his sons we are told§ that when Bharata had to choose a ship to embark in he selected one having the *swastika* as its symbol. The Ramayana poem was extant (although then unwritten down) five hundred years before the Christian era. If, then, two thousand four hundred years ago ships were afloat in the seas of Asia bearing the sign of the sun-god as an emblem of "good fortune," is it at all curious that a maritime people like the sun-worshipping Maoris should give their warships a benediction by carving on the bow-piece a symbol known in ancient time all over the world?||

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* "Rig-Veda," v., 79, 9.

† "Rig-Veda," i., 134, 4.

‡ "Fairy Mythology," Appendix, p. 513.

§ "Ramayana," vol. ii., p. 348, ed. Gorresio.

|| I have to acknowledge my indebtedness in this paper to Mr. Thomas Wilson, the learned author of a monograph on the *swastika* in the report of the Smithsonian Institution, 1894. To him I owe many of the references and examples of forms of the cross. It would be a waste of time for a student in the colonies to attempt to glean after Mr. Wilson in such a field, and so I have drawn upon the intellectual granary he stored up in his paper for inquirers to use, and value in the using.—E. T.

Art. XXXIV.—*Maori Origins.*

By Elsdon Best.

[*Read before the Auckland Institute, 6th November, 1899.*]

The following disconnected notes on Maori origins have been culled from many manuscript books in my possession containing a great amount of matter concerning the mythology, history, &c., of the Maori people of New Zealand. The search for and gathering-together of such sporadic notes requires a considerable amount of time, and when put together they do not make a by any means harmonious whole, but I hold that we who dwell in the dark places of the earth should strive but to collect and place on record all such matter, and leave higher forms of compilation and all generalising to those who have no means of obtaining such matter at first hand—or to a future generation.

Origin of the World.

According to the Maori cosmogony the world grew from primal chaos, darkness, and nothingness. The genesis or growth of the world has been likened to that a tree. Names are given of primal beings who brought forth offspring of a like nature, even until Rangi and Papa (heaven and earth) were born or came into existence. It would, however, appear probable that these primal names represent periods of time rather than beings of an anthropomorphous type. From Te Pu (the very origin) sprang Te More (the tap-root). From Te More sprang Te Weu (the rootlets or fibrous roots). Then came Te Aka (the creeper or vine). Then Te Rea (the increase). Then Te Wao-nui (the great forest or tree). Then followed Te Kune (the forming, the conception). Then Te Whe or Wheke, which represented sound. Then Te Kore (void) and Te Po (darkness).

Born of the void and darkness were Rangi and Papa, the Sky Father, the Earth Mother. From these sprang Tane, Tu, Rongo, Wainui, and Tangotango. Tane is the origin of forests, the tutelary deity of birds and trees. Tu is the supreme god of war, while Rongo presides over the food-products and the arts of peace. Tangotango is the cause or origin of night and day, while Wainui is the mother of waters, the origin and personification of streams, lakes, and the great ocean.

From Tangotango sprang the sun, the moon, the stars, and phosphorescent light. Tangaroa, the Polynesian Neptune, is

said by some to have been born of Rangi and Papa, by others to have been the offspring of Tane and Hine-rauamoa. Another child of Tane was Hine-te-iwaiwa, who was the origin of the art of weaving, and is patroness and tutelary deity of the Whare Pora, or weaving-house. She is also invoked in matters connected with childbirth.

Another wondrous being of the misty past was Ruaumoko. He is the origin or cause of earthquakes and the change of seasons. When the descendants of the Sky and of Mother Earth quarrelled and were separated and dispersed, then Ruaumoko was sent below to the under world, where he still is. When he turns over, that is the origin of earthquakes, and he changes the seasons by turning the warmth or cold uppermost. Should a Maori feel an earthquake, say towards the close of winter, he will say, "The warmth has been turned uppermost; warm weather is coming."

Origin of Death.

Maui, the demi-god, and Hine-nui-te-Po, Goddess of Hades or the under world, strove together as to whether death should be allowed to assail mankind. Maui held that man should but die as the moon dies—that is, that when his strength and faculties waned he should return to youth and vigour by bathing in the life-giving waters of Tane. But Hine said, "Not so. Let life be short for man and death eternal, that he may be wailed over and lamented." And Maui heard that Hine was slaying mankind by means of her dread arts, and as she slew men (through the wizards of old) this was the invocation heard:—

> Ka kukuti
> Ka kukuti nga puapua o Hine-nui-te-Po
> Ka whai toremi.

Then the thought came to Maui that he would gain eternal life for man. He would descend to the realm of Hine and endeavour to wrest from her this great prize for man; for so should his name go ringing down the ages. He would enter the body of the dread goddess and obtain her *ngakau*. So should man retain life and know not death.

The word "*ngakau*" means the entrails, but also is used for the seat of affection and of pain. Thought proceeds from the *ngakau*. To the old-time Maori the emotions were seated in the *ngakau*, or *ate* (liver), or *puku* (stomach), and to a certain extent in the *manawa* (heart), as observed in the expression *manawa wera*, seared, or, rather, inflamed, heart, used to denote anger or indignation. Some authorities state that it was the *manawa* (heart) of Hine which Maui strove to possess himself of. *Manawa* is the material heart, or the breath. The

manawa (heart) is the origin and seat of all knowledge, power, intellectuality. It imparts strength or vigour to the emotions and thinking-power of man. It is the origin of strength, physical and mental. The eight *pu manawa* of man are what we should term eight talents. As old Tamarau of Tuhoe watched a man dispose of three large glasses of beer in quick succession he said, "*Ko te manawa o te pakeha, he pia*"—*i.e.*, "Beer is the source of the white man's strength (or vigour)." *Manawa* is also used in another sense. In speaking of a child recently dead a man said, "The *manawa ora* has departed, the *ahua* (semblance) alone remains." Here, I take it, the *manawa ora* means the breath of life. Again, when the notorious Makurata case occurred at Galatea the *kuia* said to one who vainly tried to save her from the Pu Taewa and Christianity, "You are my *manawa ora*." Here the term really meant "salvation" or "hope"—that is, the one who gave her strength.

Anyhow, Maui failed in his greatest and final task, and was slain by the remorseless Goddess of Hades. Hence death came into the world. This also was the origin of wailing and lamentation for the dead.

The origin of treachery was the slaying of Tutunui by Kau-niho-haha (or Kae), for an account of which see Grey's "Polynesian Mythology."

The origin of cursing was Rona. When she went to obtain water at night she cursed the moon for not showing more light, hence she and her sister were taken by the moon, where you may still see them.

Origin of Theft.

Far away in the land of Mataora dwelt Pani-tinaku, wife of Rongo-maui. Pani was a sister of Tangaroa-i-te-rupetu, who was father of the Maui brothers. The fame of the *kumara* (sweet potato) came from afar, and Rongo-maui went forth and visited the regions of the sky, where Whanui* dwells, for Whanui it is who gives the *kumara* to mankind. And as Rongo-maui ascended to the sky he repeated the following invocation:—

E Para E!
Tukua atu au kia puta
Ki tawhangawhanga nui
No Rangi, no Papa
He aio.

When Rongo reached Whanui he said, "I have come for some of our children (the *kumara*), that I may take them back to Mataora with me." But Whanui said, "I will not consent

* Whanui = the star Vega.

to their being taken." Then Rongo retired, and in doing so managed to secure some of the *kumara* by stealth, which same he brought back to Mataora with him. Such was the origin of theft.

The foregoing is an interesting legend when studied in its entirety. According to the old-time Maori it was Whanui (Vega) which gave unto them the *kumara* (sweet pôtato). When Whanui first appeared in the east the wise men pronounced the *kumara*-crop as ready to be taken up. It is possible that the Polynesians first obtained the *kumara* from South America, in which direction Whanui rises.

Origin of War.

The real origin of war was the quarrel between the sons of Rangi and Papa, when Tane, Tu, Tangaroa, and Tawhirimatea strove against each other on account of the cultivation known as Pohutukawa, which, according to the aged Hamiora Pio, of Ngati-awa, meant the world. The offspring of Earth and Sky were struggling for possession of the fair earth. Rongo was the peace-maker. Had man but followed the advice of Rongo then would war have been an unknown quantity in this world, and all would have followed the arts of peace. Rongo was the origin of cultivation and of cultivated food-products. Pani gave birth to the *kumara* and made it known to mankind, but it existed before that time in far-distant lands.

I take it that Rongo was the mythological origin of the *kumara*, but that the Pani and Rongo-maui legend is a distorted account of the obtaining of the *kumara* from the east, and, as Wh'anui rises in that quarter, it came to be said that Rongo-maui had visited Whanui in order to obtain the valued food-product.

The quarrel of the sons of Earth and Sky is said by some to have arisen over the house known as Te Tatau-o-rangiriri. But Rongo and Ioio-whenua and Putehue were averse to war, and so migrated to Whitiwhiti-ora. But the fierce struggle between Tane (origin or tutelary deity of trees and birds) and Tangaroa (Neptune) was most bitter. Myriads were slain on either side. Tane destroyed the offspring of Tangaroa by means of net and hook. The tribes of Tane fell before the snares of Tangaroa. And, yet more dreadful, each ate of the other's dead. Such was the origin of cannibalism. So war raged across the earth, and many troubles afflicted mankind.

The origin of revenge was the act of Tawhaki, who ascended to the heavens in order to enlist the services of the hosts of the skies to aid him in avenging the death of his parent Takotako, who had been slain by the tribes known as Te Papaka-

wheoro and Te Tini-o-te-makahua. These people also seriously injured Tawhaki, by burning him at the place called Tarahana.

The origin of the whirlwind was the rainbow-god Kahukura. This rainbow is always a double one. The brilliant one underneath is the female; her name is Tu-awhio-rangi. The male is Kahukura. Their offspring is the whirlwind which gyrates through space. When we see the whirlwind it is a sign that visitors are coming. The rainbow is a weather-sign of the Maori people. The parents or origin of the rainbow are the *imu-rangi* seen on the horizon and Tuhirangi (the redness of the horizon).

When Tawhaki ascended to the heavens in order to gather the legions of men and dogs therein, he demanded of Whaitiri that the thunder of heaven should resound. This was the origin of the great power possessed by the priests of old, who could cause the thunder to roll at their call.

Art. XXXV.—*A Name for a Spider.*

By Edward Tregear.

[*Read before the Wellington Philosophical Society, 20th March, 1900.*]

Many investigators are leaving behind them the school that teaches how, in the study of modern savages, light on the customs of the ancients may be found. Almost every thorough inquiry into the beliefs and customs of supposed barbarians seems to convince one how little we know of them, and how little they know of the origins of their own practices. Publications lately issued on the subject of the native tribes of Australia have thrown a dazzling search-light on our ignorance concerning those tribes, and serve to show that, instead of low savages, easily understood, and with no religious beliefs worth speaking of, they are in possession of institutions which, as regards their theology, marriage-rites, initiations, &c., have imbued them with notions of the most complex nature. They have apparently in an abraded or worn-down form mystical ceremonies and beliefs compared with which an ordinary European's guiding courses of conduct are simplicity itself. Moreover, they, by a thousand lines of direction, appear to point to highly organized systems in the remote past, and therefore for us to regard such people as primitive unspoilt children of nature, in whose artless habits may be read the

interpretation of and reason for our own distant forefathers' thought and belief, should only provoke a smile. We may be unintentionally misled also by the native himself, who, unless exceptionally well informed, may give us his explanation, and be therein as thoroughly mistaken as we should be in some wild guess of our own. Take, for instance, cannibalism, and hear it explained by different observers and inquirers. One, after talking with native cannibals, explains that it arose from the desire for revenge; another because the courage, strength, &c., of the dead man can be inherited by the person eating the body. Still another teaches that it originated in scarcity of food. In fact, each native supplying the information believes that he is telling the truth, but he is absolutely ignorant of the reason why, perhaps ten thousand years before, his ancestors began their indulgence in human food. It may have arisen at funeral ceremonies, where, as in Hawaii, a dead chief was devoured by his own family only, or it may have been through some mysterious rite of communion, such as "eating the god," known to different barbaric peoples. In any case the origin is wrapped in mystery and the dusty cloud caused by the procession of countless centuries. Customs, beliefs, usages of savages should all be carefully noted and recorded; but the deductions, the theories of origins, &c., arising therefrom should be very carefully and thoughtfully considered.

If this is true in the realm of anthropology, still more cautious should be the inquiry into the realm of etymology. I believe that the man who gives an authoritative etymology of any word at all is a very bold man, and if he does so outside the lines of historic linguistics he is even a reckless man. Take up an English etymological dictionary written by a master and note how often he has to write "derivation unknown." Then, again, how short are some of the etymological pedigrees; they reach back two or three centuries and then are lost. Again, there are those words which, though not bearing the label "derivation unknown," plainly show that they ought to have such a label, for their explanation is evidently pure guesswork. Even of those words which in the hands of men like Professor Skeat are the most reliable in the language, again and again there are instances where results have to be altered in the light of later knowledge, so that an etymological dictionary twenty years old is a thing to be handled with discretion. If, then, it can be said of the classical or the European languages that their etymologists are daring men, it is borne in upon the student that one who gives at present any Polynesian etymologies is simply a fool. Of course, I do not allude to mere translations or explanations of words. It may be, for instance, quite true that the

translation of *wai-rarapa* is "flashing water"; but if we go further and try to trace *wai* and *rapa* to their source, giving a derivation for either of the words, we shall be, in our present state of knowledge, very devoid of wisdom. I say this as a preface to laying before you a sample of the difficulties besetting the pursuit of etymologies. I doubt the native exponent of the primary meanings of words just as I doubt the native explanation of some immeasurably ancient custom. The native will tell you something, but how did *he* know? Unless his knowledge is guided by some tradition whose authenticity is indubitable (and they are few), he is simply guessing, misled by sound-resemblance—keen guessing perhaps, but without a substratum of fact, and perfectly incapable of proof. This applies to all languages, not to Polynesian only. Panini was, doubtless, a reliable as well as an ancient grammarian of the Sanscrit language; but when there is a question as to the real root of a word I should prefer the opinion of a modern scholar, with the light of comparative philology falling on his work, to the most authoritative dictum of the most learned Brahmin. I have shown in a former paper* how it is almost certain that the Maori word *ua* (rain) was a worn-down form of *surangi*, and I have now a more curious series of transpositions to show. No one would be likely to consider from mere sound-resemblance that such Maori words as *rau*, *pungawerewere*, *nape*, *ranga*, and *here* were of common origin or closely connected with each other.

I was led to consideration of this subject when reading a Spanish book, "El Sanscrito en la lingua Tagalog," by the well-known linguist Don T. H. Pardo de Tavera. One thing in the work particularly attracted my attention—viz., that the Tagal words given by him as allied to Sanscrit seemed to arrange themselves into two divisions, early and late Sanscrit. Of these, the long compound words have been apparently adopted by a late borrowing, but the shorter words are such as those found scattered through the Malay Archipelago. Crawfurd noted some of these, and they may fairly be classed as a stratum of language underlying the Malay and other tongues that were brought down in the Mongolian invasion from Asia. This stratum is composed of relics of that mother speech of Arya that preceded Sanscrit, as it preceded all European languages. Such words as Tagal *acsaya*, "to destroy, disperse," is probably the Sanscrit *kshaya*, "slow destruction, ruin" (as the Kawi *akshama* = Sanscrit *kshama*), and Sanscrit *bahala*, "a hundred millions," is the Tagal *bahara*, "a weight of 150 kils.," through Malay *bahara*, also a mea-

* Trans. N.Z. Inst., vol. xxiii., p. 543.

sure of weight. The Tagal *castoli*, "musk," is the Sanscrit *kasturi*, "musk"; the Tagal *bangsi*, "a flute," is the Sanscrit *vançi*, "a flute." With such words as these the Polynesian language has little affinity; they are too modern; but as soon as we get into the shorter and more radical words the Polynesian conveys the older form far better than the Tagal does. The Polynesian *vaha*, "to carry," is far nearer the old root √VAH, "to carry," than the Malay *bawa* is; while the Polynesian *rapa*, "to flash" (Aryan, √LAP, "to shine"), and *kapa*, "to flutter" (Aryan, √KAP, "to vibrate"), may serve as examples of closer affinity to the ancient root than any Tagal form can show except in the later groups of borrowed words.

It is not, however, my intention at the present moment to discuss this question, as the evidence is very voluminous, and it is beside the present point, which is, that one of Don Pedro's words, though late Sanscrit, leads to some very interesting disclosures in word-relationship. He points out that the Tagal *lalaua*, "a spider," is the Sanscrit *lalasrawa*, "a spider," and that it has taken this form because the letters *sra* in the middle of a word are very difficult for a Philippine native to pronounce. This may be so, and, if the connection is a fact, supplies us with a valuable link in regard to the unsuspected relationship both of Malay and Polynesian with a Sanscrit word in this instance. The Malay has both *lawalawa* and *labalaba* as "spider," and the cobweb is called *sarang-labalaba* in Malacca (*sarang* = "nest"), as in the Sulu Archipelago, where "spider" is *lawalawa*, the web is *lawai-lawalawa*, a double compound of the word. The Bisaya (another Philippine dialect) has *lawa*, "a cobweb"; but where the Tagal word is so valuable is in the first syllable, for the *lawa* requires the prefixed *la* to connect it properly with Sanscrit *lalasrawa*. Monier Williams, in his large Sanscrit dictionary, tells us that *lalasrava* means "distilling saliva," and "spider," from a root √LAL, "to play, sport, to loll the tongue," and hence such words as *lāla*, "saliva," *lalaya*, "to emit saliva." But if we admit that the Malay *lawalawa*, "the spider," is a variant of the Tagal *lalaua*, "a spider," or Tagal *lawalawa*, "a spider's web," we have also to admit the Lampong *lawah*, "a spider," the Sangi-Manganitic *lelāwah*," "a spider," and the Timorese *naba*, "a spider," because this latter makes a frequent *l* to *n* change with Malay. The Malay *laba* becomes Timorese *naba* by a rule, just as Malay *lilin*, "wax," becomes Timorese *nini*. Malay *lima*, "five," is Timorese *nima*, &c. This is also a Polynesian letter-change, as the Tongan *neka*, "joy," is the Maori *reka*; the Tongan *nima*, "five," the Polynesian *lima*; the Hawaiian *ununa*, "a pillow," the Maori *urunga*, &c.

If we pursue the Malay words *lawalawa* and *labalaba* into Polynesia we arrive at some curious results. We do not find the word in its proper form and meaning, although we have it as a compound in the Fijian *virita-lawalawa*, "a spider's web." The Hawaiian *lawalawa* does not either mean "spider" or "cobweb," but its signification shows that it applies to actions resembling a spider's work. Thus it means "to stretch cords from one place to another; to fasten something"; (2) "to bind, as a grass house or anything in danger"; (3) "to bind round and make fast." This dialect appears to have substituted *n* for *v* in direct words for spiders, thus we have (instead of *lawalawa*) *lanalana*, "the name of a large brown spider that stands high on its legs"; (2) "a rope with which the outrigger of a canoe is tied to the arched connecting-poles"; (3) "to cause to float." *Lana* is "to float, to swim in the air or on the surface of the water; buoyant." Also, to complete the resemblance in Hawaiian (and show the looseness of *l* and *n*), *nanana*, "the long-legged spider"; (2) "to swell up, as the abdomen"; (3) "a spider's web": *punanana*, "a species of spider"; (2) "the spider's web." But with this last we revert to the Malay form, for with the Hawaiian *pulawalawa*, "bound tightly and firmly, as a thatched house with cords from post to post," shows the original idea of a web-like cordage. Note, however, that the Hawaiian *lanalana*, "the spider," is the direct equal (according to the Polynesian 'Grimm's Law'—viz., Hawaiian *l* and *n* represents Maori *r* and *ng*) of the Maori *ranga* and *raranga*, "to weave."

I need not remind my readers of the connection always maintained in classical poetry and legend between the spider and the weaver, the spinner and the web. Even in our vernacular we speak of "the web" on the loom, and the fable of Arachne has blended itself with almost all thought on the subject. Not only in Maori but in other Polynesian dialects does the idea of weaving pertain to the word *ranga*. We have the Samoan *lalaga*, Tahitian *raraa*, Tongan *lalaga*, Paumotuan *raraga*, Mangarevan *raraga*, all meaning "to weave," and also the Futuna *lalaga*, "to weave," *lagalaga* "to weave a basket." So that the words which in Hawaiian mean "spider" and "web" become in other dialects the words for "weaving."

This is strengthened by the Timorese word *naba*, "a spider," shown above as being a form of Malay *labalaba* or *lawalawa*, for this word strongly suggests the Maori word *nape*, "to weave," arose from a root √NAP or NABH (a variant of √LAP or LAV), as in the old Sanscrit root √NABH, "to bind, to connect." It appears again in the Tongan *nabe*, "a method of plaiting sinnet," and in the Pau-

motuan *nape*, "to weave," "a tress or plait," and in the Samoan *nape*, "to be entangled," *fa'a-nape*, "to tie loosely."* If the final vowel be objected to, I would point out that the Samoan *nape*, "to be entangled," has another form (*lave* or *lavelave*, "to be intertwined, intricate"), and that Lorrin Andrews, in his Hawaiian dictionary, shows that *lawa* is sometimes *lawe*, as in *lawaia*, "to take fish," from *lawe*, "to take," and *ia* (Maori *ika*) "fish." In another Hawaiian example we have *lawelua*, "to tie up a second time," which is from *lawa*, "to tie up," and *lua* "twice." Also the Tongan *lalava*, "to bind with sinnet," is the equivalent of Samoan *fa'a-lave*, "to take a turn of a rope round something," and Sunda (Java) *lawe*, "thread for weaving."

It is, however, in metathesis that the strangest confirmation of the connection comes out. In the Motu (a Polynesian dialect in New Guinea) *valavala*, "a cobweb," we have an exact transposition of *lavalava*, and this *valavala* varies in other places with *velevele* or *werewere* in a dozen curious ways. In the Maori *pungawerewere*, "a spider" (also *puawerewere* and *puwerewere*); in the Tahitian *puaverevere*, "a cobweb" and "gauze"; in Marquesan *punaveevee*, "spider" and "cobweb"; and Mangaian *pungaverevere*, "a cobweb," we have one form. In the Samoan *apugaleveleve*, "spider" and "cobweb"; in the Tongan *kaleveleve*, "a large spider"; and Futuna *kaleveleve*, "a spider" and its "web," we have the other. But to make assurance doubly sure we have also the Sinangolo (New Guinea) *kavalavala*, "a cobweb," which is the original vowel again. In the Paumotuan *pugaverevere* means "cloth," again showing the connection between the cobweb and weaving. The *kaleveleve*, "a spider," above noted, has its Hawaiian affinity in *kawelewele*, "the names of certain short ropes about a canoe," and "the beard"; but in this dialect *punawelewele* is the "spider" and its "web" as before, but with an addition well worth notice, for Lorrin Andrews gives us an etymology of a sister-word. He says, "*Punawele*, to be small in size, to be fine, as threads of spiders' webs. From *pu* and *nawele*, to be fine or small." I cannot help thinking this derivation doubtful, because *punapuna* means "made fine, scattered, blown away," and *punawe* "to divide," which latter is a form of *puu-nauwe*, "to divide into parts or parcels," evidently from *puu*, "to heap up," which, in its causative form *hoo-puu* (Maori *whaka-puku*) means "to heap up, as stones, to cast lots, to divide a country

* Probably also in the Aneityumese *nap*, "a native mat," and *napamas*, "bark cloth," or *tapa*; *napevak* or *napavak*, "a native mat"; but these are doubtful, because the initial *n* may here be a remnant of the prefix of nouns which we find as *inwai* for "water" (the Maori *wai*), &c.

by lot"; so that the division is not *pu* and *nawele*, but *puna* and *welewele*.

In Maori *werewere* means "hanging, pendulous," and appears related to *here*, "to tie up," "to fasten with cords," and generally in Polynesian (*hele*, *sele*, *ele*, *ere*, &c.) to words signifying "a snare or noose." The Tahitian *verevere* means "thin, gauze-like," and the Fijian *vere* "entangled, confused," *vereverea* "intricate, entangling," the Easter Island *vere* "the beard," and Aulua (New Hebrides) *verevere* "a fishing-line." (The Maori meaning "hanging, pendulous" shows a reversionary implication with the other Indo-European value of the root √LAB—viz., "to droop, hang down," which, in English, gives us "lobe," "limp," &c.) These meanings of *vere* make it likely that *pungawerewere* or *pualeveleve* did not originally apply to the spider but to its web—to the fine capturing-lines of the cobweb.

If, as we have seen above, *lawa*—in Hawaiian, "to bind"—exchanges with *lawe*, "to take"; if Maori *rawa*, "goods, property," is related to *rawe*, "to acquire property," then Maori *rau*, "to catch in a net," is probably on the same root—viz., √RAB or LAV (the Indo-European root √RAB or LAB, "to seize")—and the radical meaning of Malay *lawalawa*, "the spider," is "seizing, catching."

This, then, brings us to the only consideration that results from the diligent pursuit of the word through Protean changes—viz., Is the word Asiatic or Oceanic? Did the Indo-European word *lalasrava*, "a spider," losing its original meaning of "distilling saliva," work its way eastward to the Malay Islands, the Philippines, and the South Seas? Or is it possible that the Polynesian word *ruvarava*, or *varavara* (or *velevele*), meaning "seizing," passed through those islands in a westerly course and "went ashore" in Asia, to be adopted by a people speaking an Aryan dialect, and to be altered in pronunciation slightly, so as to fit a supposed etymology from words signifying "distilling saliva"?

ART. XXXVI.—*Of a Radiant Phenomenon: "In hoc signo vinces."*

A Fragment left by the late W. COLENSO, F.R.S., F.L.S.

[*Read before the Hawke's Bay Philosophical Institute.*]

MEMORANDUM.—31st May, 1892: Returning this day by the express railway-train from Woodville to Dannevirke in a thick fog, I was suddenly struck with admiration and delight on seeing the exact image of the letters "N.Z.R." and of the whole ornamental and coloured glasswork in the upper lights in the narrow raised roof clearly and beautifully shown high up in the foggy air, in altitude far above the roof of the carriage, and on its eastern side. Every fine and delicate line and point of tracery was most distinctly produced, without any blurring or scumbling, and such was also continued, notwithstanding the rapid progress of the train, throughout its running in a straight direction, or in one suited to catch and reflect the beams of the sun. Of course, when the carriage deviated to the right or to the left the image vanished, but it was sure to reappear on the train again running in that same direction; and when the train stood still at any of the stations and keeping the same course the image was fixed. This happened between the hours of 12.45 and 1.15, when the sun had declined but little from its highest altitude (though naturally low in the heavens at this midwinter season), and when it was shining brightly through rifts and breaks in the dense fog and scattered white clouds; at times also the imagery was highly illuminated, becoming of a brilliant-red colour, and largely magnified. And again, when the sun shone out strongly, being quite clear of fog and of clouds, the reflected images were remarkably vivid-red, dazzling the eyes. At such times the image of the sun itself would also be represented by an additional brilliant round and bright-red figure, partly encircling the other reflections, on which the eye could not remain momentarily fixed: this, however, was transitory. Sometimes the appearance of the legend "N.Z.R.," with its accompanying delicate ornamentation, was agreeably changed in its colour, becoming merely dark on a dead frosty-white background. And when the fog had wholly cleared away the same pictures were again vividly and faithfully produced against the deep-blue and clear sky: and all this show continued for a considerable time—more than half an hour.

Naturally it led me to think on the famous legendary sign in the sky, said to have been seen by the Emperor Constan-

tine, A.D. 312, and I exclaimed, "*Ecce signum!*" and the question arose in my mind whether that appearance in the sky was not caused in a similar kind of natural manner—by the sun's rays striking down on such a device, which might have pertained to some one of the Emperor's legionaries, and so reflected it high up in the sky.

Considering this matter has led me to look up what ancient history says of that famous sign (which I had nearly forgotten), and I find—(1) That it was not the sign of the cross at all as we moderns understand it; (2) that it was not even thought so much of at the time it was said to have happened; and (3) that those historians who were then living have given differing accounts of it, and also of the time or season of its occurrence.

As this story is, I think, little known to my audience, and also liable to much doubt, I will briefly mention a portion of what has been said about it.

But first of Constantine himself. At that very period he was not a Christian. This is clear from Eusebius (Bishop of Cæsarea), who, in his life of the Emperor (with whom he was in great favour), says, "In the commencement of his war with the Roman Emperor Maxentius he was still at a loss to what god he should trust himself and his affairs."* He was a deist of the lowest class, who considered the god of his father as a limited being, though more benevolent and powerful than any of the Greek and Roman deities. This is manifest from his regulations in favour of the Christians and from his laws tolerating the Pagan haruspices.

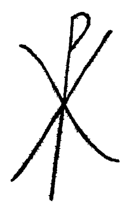
There is great difference of opinion as to the time when, and the place where, the Emperor saw this sign. According to Eusebius he saw it while in Gaul, and when making preparations for the war with Maxentius. Lactantius, however (a celebrated Christian historian and contemporary), states that Constantine saw the cross on the 26th October, 312, the day before the battle in which Maxentius was vanquished near Rome.† Others (ancient writers) would compromise it by supposing there were two appearances of the cross, and both in dreams—the first in Gaul and the second in Italy. Again, some suppose it was a pious fraud, and others that it was a trick of State. The first supposition is most improbable, for at the time the cross is said to have appeared to him Constantine thought nothing about spreading the Christian religion, but only about vanquishing Maxentius. Besides, he was not then a Christian, and the event was not used for the advancement of Christianity, but for the animation of his

* Eusebius, "De Vitâ Constantini," *l.* i., *c.* 27.
† De Mortib. Persecut., ch. 44.

troops. The other supposition has more probability—indeed, we are told by Lactantius (*l.c.*, ch. 46) that the Emperor Licinus (brother-in-law of Constantine) once resorted to something of this kind. But if Constantine had been inclined to use artifice in order to encourage his soldiers he would far more probably have represented Mars, or some other of the common deities.

An ancient writer has observed, "This sign is a subject involved in the greatest obscurities and difficulties. It is, however, an easy thing to refute those who regard this prodigy as a cunning fiction of the Emperor, or who rank it among fables; and also those who refer the phenomenon to natural causes, ingeniously conjecturing that the form of a cross appeared in a solar halo, or in the moon: and likewise those who ascribe the transaction to the power of God, who intended by a miracle to confirm the wavering faith of the Emperor. Now, all these suppositions being alike rejected, the only conclusion that remains is that Constantine saw in a dream, while asleep, the appearance of a cross with this inscription: 'By this conquer.'"

But the splendid, clearly defined, and wonderful reflection in the sky mentioned above as seen and enjoyed by me seems to be another and still more reasonable and natural mode of accounting for that phenomenon, which appears to have escaped the notice of former writers. Indeed, Fabricius, in his learned work on this subject, admits that the appearance of visible words in the air cannot be explained; and so he resorts to a new exposition of the language of Eusebius for relief, and believes that the words "By this conquer" (τούτῳ νίκα = *hoc vince*) were not actually seen, but that the sense of them was emblematically figured in a crown of victory that appeared in the heavens. But if the Emperor intended to say this he expressed himself very obscurely. Moreover, he caused the very words mentioned to be affixed to the standards (*labara*) of the legions, and to the medals and other monuments of the event; and, further, all the ancient writers so understood the account given by Eusebius. Again (according to Eusebius*), the Emperor did not see the sign or form of a real cross, but the Greek letter χ intersected perpendicularly by the letter ρ, thus—Eusebius says a great deal about it, also prefacing the Emperor's personal relation to him by remarking, "Perhaps had another declared this singular divine manifestation it would not easily be credited; but the victorious Emperor himself having related it to us, who write this,



* "De Vitâ Constantini," *l.* i., § 28–31.

when we had, a long time afterwards, the privilege of knowing and conversing with him, and having confirmed it with an oath, who can hesitate to believe the account?" Then Eusebius goes on to enter into it very minutely, as he had the story privately from the Emperor's own lips, who affirmed "that about the middle hours of the day, as the sun began to verge towards its setting, he saw in the heavens with his own eyes the sign, with its legend, and amazement seized him and the whole army at the sight, and the beholders wondered as they accompanied him in the march." And he said "he was at a loss what to make of this spectre (τὸ φάσμα), and, as he pondered and reflected on it long, night came upon him by surprise," &c.

Now, if this relation is all true, how happens it that no writer of that age says one word about the luminous cross in the heavens? Lactantius mentions only the "dream," in which Constantine was directed to use the sign of the cross; and the same is true of Sozomen (*lib.* i., *c.* 3), another ecclesiastical historian; and Rufinus, and others. Hence, too, it seems that the whole story was counted fabulous by the Pagans, which confirms the ancient statement and supposition that it was a dream. How came it that Eusebius himself said nothing about it in his "Ecclesiastical History," which was written about twelve years after the said event, and about the same length of time before his "Life of Constantine"? Why does he rely solely on the testimony of the Emperor, and not even intimate that he ever heard of it from others, whereas, if true, many thousands must have been eye-witnesses of the fact? What means his suggestions that some may question the truth of the story; and to confine himself simply to the Emperor's private representation to himself? And how came the whole story of the luminous cross to be unknown to the Christian world for more than twenty-five years, and then to be made known only through a private conversation between Eusebius and Constantine?

Here I may observe that the hour of the day, and almost the season of the year (as stated by Eusebius), and consequently the position of the sun in the heavens, pretty nearly correspond with the time and season in which I first noticed the phenomenon. Moreover, the onward movement of the train did not interrupt its appearing; and this also agrees with the march of the army. Further, the occasional refulgent image of the sun itself surrounding the other and darker imagery (as witnessed by me) serves to remind one of one of the ancient suppositions respecting that spectre seen by Constantine as being a solar halo. Of course, I do not mean to say that this which I have here adduced is the true solution of that old mysterious story, but merely that it has much

more of natural and reasonable supposition in it than any other (as far as I know) yet brought forward. And, further, the peculiar and true form of the so-called cross, or sign, as clearly given by Eusebius, both in words and in a figure, seems not unlike in outline that of a disarranged and mutilated bundle of fasces as borne by the Roman lictors, with the small axe jutting out from the top instead of the middle of the broken bundle. Now, supposing the particular date of the sign being seen as given by Lactantius to be correct, would such a figure as a spoiled and broken bundle of fasces be considered as an ill-omen against Maxentius and the Roman army?

In fine, I may add that I have very often since seen the same reflected figures when travelling over the same ground in the express train on sunshiny days, though never so beautifully and vividly shown as on that day of dense white fog. I dare say that many other passengers may also have noticed it, though to see it at all one must keep close to the glass window and look up above the altitude of the carriage, and there, with attention and a fixed gaze, watch for its appearance.

ART. XXXVII.—*Memorabilia, Ancient and Modern; being Remarks and Information respecting some of the Tin-mines in Cornwall, England.*

A Fragment left by the late W. COLENSO, F.R.S., F.L.S.

[*Read before the Hawke's Bay Philosophical Institute.*]

> The minerals of the kingdom, of lead, iron, copper, and tin, are of great value.
>
> BACON.
>
> ——valiant as a lion,
> And bountiful as mines of India.
>
> SHAKESP., *King Henry IV.*, part i., act iii., sc. 1.

FOR some time past I have been desirous of bringing before you a few statements and remarks on the tin-mines of Cornwall. Several circumstances combined have induced me to attempt to do so: (1.) My being a Cornishman by descent and birth, and having still a clear remembrance and recollection of what I had there seen in connection with the mines in my youthful days (seventy years ago!), some being peculiar and but little known here at this end of the globe, and some of them very likely have become inefficient and obsolete through the continued and rapid advances of science during a long lapse of seventy years. (2.) Certain public occurrences

that have lately taken place both here in New Zealand and in Australia—as the rich gold-mining at Coolgardie and other places in Australia and in the Thames district in New Zealand, and also the great number of the unemployed everywhere among us; these two diverse matters considered together with what has recently taken place in connection with the mines at Home in Cornwall, of which I intend more particularly to speak in this paper. (3.) My possessing some interesting specimens of tin-, copper-, lead-, and iron-ores from the Cornish mines, which I should like to show you (these mementoes from Home have been in my possession nearly sixty years, having been early sent to me by my uncle, the father of the late Bishop Colenso, of Natal, who for many years held the office of Mineral Agent in the Duchy of Cornwall).

The County of Cornwall, as no doubt you all well know, is both the southernmost and westernmost county of England. It is of peculiar configuration in its outlines, long, narrow, and irregular, being surrounded on all sides but one by the ocean for more than seven-eighths of its total circumference, save where it joins on its eastern end to the County of Devonshire, which is also its broadest part. The westernmost headland or extremity is the Land's End, and the southernmost point or cape is the Lizard—often the last portion of Old England seen by the voyager or emigrant on his leaving the old Mother-country for New Zealand.

Geologically speaking, the country is very rocky, the principal stone being granite.

Cornwall has long been famous for its tin. We find in the earliest histories that the Phœnicians traded into Cornwall for tin before the invasion of Britain by Julius Cæsar, or, in other words, long before the Christian era. But I am not, at present, going into the ancient history of Cornwall—of its distinct people and language, or of its Druidical and prehistoric remains; valuable information on these subjects may be obtained from books in our library. I shall confine my remarks to the proper subject of this paper—viz., its mines and staple industry of mining.

Tin-ore is obtained by two principal processes, which are widely different from each other; the one is called "mining," the other "streaming" ("tin-streaming"). The first, or mining, is carried on by sinking deep shafts perpendicularly in the earth, and by following in every direction the course or veins of the metal tin, often horizontally and irregularly disposed in the granite and other stones. This mode of mining includes many modern and scientific operations, and can only be carried out at an enormous outlay. The ore—that is, the metal in the stone—when brought to the surface has to be

broken up into very small fragments by powerful machinery, and the tin extracted. This class of mining gives employment to many hundreds of labourers, including women and children. The second mode, or streaming, is much more primitive and easy. This may be termed "surface work," as it is generally carried on in moorland plains and valleys, in shallow pits of only a few feet in depth, and at but a small distance below the surface of the ground. The tin is here found deposited in blackish sand-like particles, in small, worn, brown lumps or pebbles, with occasionally a few larger pieces. I have seen such pieces (or nuggets) of almost pure tin weighing from 12 oz. to 20 oz. The variety known as "wood tin" is of a lighter colour, variegated, striped, and pretty. Tin thus procured is cleaned from sand and earth by simply washing in water, as from its great weight and purity it speedily sinks, when it is collected and laid out to dry.

A large number of tin- and copper-mines are irregularly scattered all over the county, but more particularly in its western half, some being romantically situate on the top of high hills, sea-cliffs, and crags. The mines in the Parish of St. Just, near the Land's End, are among the most remarkable in Cornwall, no less from the great variety of unusual minerals which they have produced than from the fact of the direction of the veins seaward having tempted the miners to follow them to long distances under the billows of the Atlantic Ocean. From among them I would especially mention three —Botallack, Levant, and Dolcoath; these being also A1 among the principal metal mines in Britain. Very recently the sad news reached us that two of these mines were likely to be closed, after yielding untold wealth for nearly two centuries, the cost of working the deposits of tin and copper being now greater than the profits to be earned. If these mines closed they would throw out of occupation and livelihood more than four thousand people—men, women, and children—engaged therein.

The celebrated Botallack Mine is situate in the Parish of St. Just, about two miles from the town of that name, about the same distance from Cape Cornwall, seven miles from the Borough of Penzance, and about the same distance from the Land's End. Levant Mine is also near to Botallack, and, like that mine, is close to the sea. This one, however, is still working well, and rich. Botallack is in itself worth seeing, even if no mine existed in its recesses. It is a bold headland composed of huge masses of hornblende, marked by walls of slate, against which the Atlantic surges are continually dashing. But the persevering efforts of man have at this point been more powerful than those of nature. Here is to be seen the most striking example of man's boldness in the search of

wealth, and his skill in securing it. Gloomy precipices of slate which unnumbered ages of sea-storms have been unable to displace are here cut in twain by the miner, whose complicated machinery clings to the cliffs at places where it would seem almost impossible for an engine to be fixed. The spectator here finds himself at once in the midst of a busy community. Powerful steam-engines, a stamping-mill, and all the heavy machinery required in modern mining are perched on what at first sight seem inaccessible situations, so that from a distance they look as if growing out of the crags. All is noise and bustle, which contrast strangely with the placidity of the seaward view in calm weather. "Kibbles"* descend fathoms beneath the sea through the shafts, and ascend again laden with tin- or copper-ore, which is wheeled away to larger heaps, where women, boys, and girls pick and separate the various qualities with the systematic industry of workers in a factory. Everybody and everything—rocks, platforms, and paths—are smeared with the prevailing red hue, derived from a slight mixture of iron with the ore; and the muddy stream flowing from the stamping-mill to the sea has imparted to the beach, the breakers, and the foam the same ruddy tinge. If ore is coming up plentifully and of good quality everybody is pleased, and far down in the gloomy depths of the mine, which Cornish legends people with sprites and gnomes, the news that a new "bunch" (vein or mass) of copper has been struck, or that the old lode is growing richer, fills the workers with professional joy. As the visitor creeps along the underground passages, into which the light of day has never entered, he hears comparatively little. Having become accustomed to the darkness, barely illumined by the flicker of lamps, he dimly distinguishes the stalwart miners at work. Coming down from the upper world amid the incessant din of heavy stamps, the measured gush of pumps, the clang of machinery above and the surge of the sea below, the rattle of wagons on tramways, and the crowds of men and boys climbing up and down paths which seem too steep for a goat, the modified silence of the deep underground levels strikes one as unnatural. In places, however, the guides may ask the visitor to listen to a curious sound. It is the booming of the waves overhead, and the grating of the stones on the sea-bottom. Then he is told, to give him courage, that in some of the recesses of the first level the ore has been cut away until a roof not more than 6 ft. or 8 ft. thick has been left. First worked on the face of the cliff only, the mines descended level by level until the excavations extended for more than 600

* Large buckets.

fathoms under the sea, and for long distances inland, while the greatest depth to which it had been sunk was about 2,000 ft. It was this persevering search after ore which gave Botallack its celebrity, and that brought it streams of more or less distinguished visitors.

The Queen, with Prince Albert, visited this mine in 1846, to see what her Cornish subjects could accomplish, and Her Majesty also bravely descended a considerable distance into the mine by the common miner's way through the diagonal shaft, a kind of narrow subterranean gully or tunnel. And again, in 1865, the Botallack miners kept holiday in honour of a visit from their Duke and Duchess, whom we know more commonly as the Prince and Princess of Wales. The Duchy of Cornwall was created in 1337 for Edward the Black Prince, who became entitled to the revenues from the manors, and also the tin dues.

I may here quote, for your information, a portion of a graphic description of a visit to one of the submarine mines in St. Just during a storm: "At the extremity of the level seaward, about 100 fathoms from the shore, little could be heard of its effects, except at intervals, when the reflux of some unusually large wave projected a large pebble or boulder outward, bounding and rolling over the rocky bottom. But when standing beneath the base of the cliff, and in that part of the mine where but 9 ft. of rock stood overhead between us and the ocean, the heavy roll of the larger boulders, the ceaseless grinding of the pebbles, the fierce thundering of the billows, with the crackling and boiling as they rebounded, placed a tempest in its most appalling form too vividly before me to be ever forgotten. More than once, doubting the protection of our rocky shield, we retreated in affiright; and it was only after repeated trials that we had confidence to pursue our investigations."

The deeper workings, having a natural temperature of 70° to 80° Fahr., in some places rising to 85° or 90°, tax the ingenuity of the mine captains to introduce a sufficient ventilation; but the arrangement of numerous shafts with abundance of communication by winzes between the levels have enabled them so far to triumph over difficulties that, in several examples, we may point to a great complication of workings satisfactorily ventilated without furnaces or mechanical appliances, and yet carried out through hundreds of fathoms of excavation.

Mining is so ancient an art in Cornwall that it is often difficult to trace the beginning of any particular working in that county. It must, indeed, have often happened that openings now excavated deep in the earth, or, like Botallack and Levant, far under the sea, had their beginnings in the

rude washing of the surface alluvium known as "tin-streaming." This was the method adopted by the ancient miners for obtaining the metal which they sold to the Phœnician merchants. At all events, close to Bunny Cliffs, a little south of the present mine, there are some "old men's workings," as the remains of what are taken to be ancient surface streaming of the prehistoric races are called. As early as 1721 Botallack was wrought as a tin-mine, on the method which, with modifications suggested by modern discoveries, has been followed ever since. By 1841 it was famous as a very rich copper-mine, a reputation which it may be hoped it will some day recover, though until recently it was notable for both of these metals, or for whichever exploration brought to light in greater abundance. Since 1862 the more picturesque aspects have suffered by its being wrought more economically, and with greater sanitary efficiency, by the Boscawen shaft, which runs from near the water's edge in an oblique direction under the sea. This diagonal shaft is 400 fathoms long, and cost about £4,000. A difficulty not much less than that of sinking the tunnel, which is descended by wagons, was that of lowering the engine to its position. The Crown engine had been lowered to its exposed situation on the Crown Rocks over a cliff 200 ft. high. When, however, the 24 in. cylinder engine was first dropped on its wild exposure, over the face of a rugged precipice, it was never expected that it would undergo a second migration. But in 1863 the huge boiler and beams were, after being drawn to the top, again relowered to a new resting-place, and a house built for their reception.

It is therefore not without good ground that Cornishmen claim Botallack as one of the world's wonders. Apart from the place it must always occupy in the history of mining engineering, it will be a distinct loss to Cornwall that so extensive a concern is likely to be closed, either permanently or until times mend. But mines are at best among the most fickle of fortune's gifts, and the enormous imports of foreign tin and copper are, undoubtedly, not to the profit of the more expensively worked native mines.

As an instance of the uncertainty in tin-mining, I may relate a well-known circumstance that took place in Botallack Mine. After expending nearly £20,000 the prospect of a return seemed hopeless, as the resident agent declared to the proprietors, at their meeting in November, 1841, that "he knew not where to find twopennyworth of ore in all the mine." Several of them were therefore strongly inclined to abandon the concern, but it was eventually determined to continue it for a further period of two months, with a resolution to give up the whole in case of no improvement in that period. It afterwards appeared that, when they were thus discussing the

propriety of abandoning the concern, the workmen were within 2 in. or 3 in. of a "bunch" of copper-ore, which in twelve months yielded a profit of £24,000.

From published reports I gather that the profit on the working of Botallack from 1836 to 1865 was £102,150 in actual dividends, and on Levant, from 1830 to 1865, was upwards of £200,000.

Botallack Mine had been for some time past worked at a heavy loss. It is composed of seventeen hundred shares, and the shareholders not long ago had been called on for £1 10s. a share. This call was met; but, notwithstanding, the mine was still being worked at a great loss, the return of tin being scanty and inferior in quality, so that the directors had no desire to make another call. Lately fifty men had been discharged, but these fortunately found employ at Levant Mine, near by; and there were still 130 men and forty-four boys employed on the mine, but all working at much lower wages. There were also upwards of five hundred children dependent on the miners of this one mine. At the last adjourned meeting of the shareholders it was decided to offer the mine, with all its extensive machinery, for sale, or, failing that, to shut it up, which means a heavy blow for West Cornwall.

Having shown on a small summary scale the digging and raising of the ore from deep in the bowels of the earth to its surface, I may also briefly relate a few interesting items that follow concerning its preparation for the market, having not infrequently witnessed them all with much delight in my youth :—

(1.) The ore as it comes from the mine is taken to the stamping-mill. This mill is composed of upright beams of squared timber several feet in length, and, say, 8 in. or 9 in. in diameter, each piece being strongly shod, or armed, at its lower end with a heavy iron stamp or pestle. These posts or beams are set up vertically close together in a row, and are raised continually by water-power, and when set working soon pulverise the mass of ore below. Water is continually let in, and the stones, earth, and sand, reduced to small particles, are carried off with the tin into sloping pits and courses prepared to receive them. The tin being the heaviest sinks early, and is soon detained. This is taken up and "dressed" —that is, put into proper heaps on flat earthen floors specially prepared for its reception, where it is in due time "ticketed," or assorted, according to its purity and value.

(2.) All things being ready, the tin (in grains or sands) is put up into strong, long, narrow sacks and carried off on mules to the tin-smelting house, of which there were two in the west of Cornwall, one being at Stable-Hobba, a village

about a mile and a half to the west of Penzance, between Treneipe and Newlyn, and one at Chyandour, a village a little to the east of Penzance, and almost a suburb of it. Those sacks of tin were often carried on mules from the mines through Penzance to the smelting-house at Chyandour, and to me it was always a gladdening sight to see the drove of twenty or more mules coming steadily along in pairs, keeping step in due marching order, and bearing their heavy burdens, following the man in charge, who preceded them on horseback, their red-looking sacks of tin appearing so uniform, each sack (of which there were generally three on a mule) containing about 1 cwt.

(3.) Arrived at the smelting-house, the raw tin was melted down in large furnaces and run into regular-shaped moulds cut in granite, each block forming a parallelogram of about 2 ft. long by 1 ft. broad on the surface and 6 in. to 9 in. deep, and narrowed on all sides and on the base below, its upper surface shining brilliantly.

(4.) The next step in the process would be to carry these blocks of pure tin metal into Penzance (as one of the "coinage towns") to the "coinage-hall" there, in order to their being duly coined by the officers of the Duchy. This was done—(*a*) By weighing them separately and infixing the weight in the face of the block; (*b*) by stamping each block with the arms of the Duchy; (*c*) by clipping off a small piece (an ounce or two) from one of the corners: and now it was ready for sale, use, or exportation.

(5.) But there was still another tin-melting house, or premises, near the quay at Penzance, where those blocks of tin were (when required) again melted down and made into small tin bars or rods. This was a peculiar and pleasing process, which I will briefly describe: An open furnace, or big melting-pot, into which one of those blocks of tin was placed, being suspended on a large iron hook. Around the building, against the walls, was a row of thick flat-surfaced grey-marble slabs, each about 4 ft. long by 2 ft. wide, cramped around with iron. In the face of those slabs were cut across straight, narrow, semicylindrical grooves, very near each other, about ¾ in. wide and deep. These were carefully filled with the liquid tin, brought from the furnace in deep short-handled bowl-ladles, and poured into the grooves, which soon became solid and cooled, and were dexterously picked out singly by the workman. It was a very interesting sight to see the skilful and experienced workman pour quickly into each groove sufficient metal to fill it from his heavy ladle held by both hands, and then to pick up rapidly the shining tiny bars, still very hot, into his left hand well armed with thick woollen rags. These bars were then stacked crosswise, and looked

very pretty. Sometimes, but rarely, there would be a short or imperfect one, which, of course, would be again consigned to the melting-pot. I understood that those small tin bars were exported in that state to the West Indies and other countries as an article of commerce.

I would also remark on the peculiar appearance of the tin-smelting houses, owing to their several very high and narrow telescope-shaped brick chimneys, regularly cramped and banded with iron throughout to the top, one, of course, to each furnace. On a dark night the bluish flame that rises in the still air from the top of each chimney has a very singular look, somewhat weirdlike, and must often seem strange to the visitor or traveller by night not knowing the cause, particularly the smelting-house at Chyandour, from the fact of it being situate in a low valley close to the foot of a high range of thickly wooded hills, the dark foliage of the trees in the immediate background serving to enhance the romantic appearance of the tremulous and coloured flames of fire. Moreover, I believe those smelting-houses are often, if not generally, worked in by night.

I have said that Penzance is one of the "coinage towns" of the Duchy of Cornwall. This I will further explain. In Cornwall at present there are five coinage towns—viz., Launceston, Lostwithiel, Truro, Helston, and Penzance. These are termed in law "stannary towns," and have certain peculiar laws and privileges respecting mines and miners; and all tin raised in the county must be taken to one of them in order to it being stamped and the dues paid. The infancy of the stannaries, with which the history of the Courts is almost inseparably interwoven, is obscured by the "purple haze of antiquity." Gilbert, in his "Historical Survey of the County of Cornwall," observes that the "hand of time, united with the loss of the first charter and the destruction of many stannary records at Lostwithiel in the unnatural times of Charles I., have thrown an air of obscurity, doubt, and uncertainty on the stannary laws which it would now be a difficult, if not impossible, task to remove." There is a consensus of opinion that the word "stannaries" is derived from the Latin *stannum* = tin, but it is believed by some it comes from *stean*, the old Cornish word for tin. It would seem that the formation of Stannary Courts followed hard upon one of the recurrent periods of activity in the production of tin a century or two after the Norman invasion. The tin-mines of Cornwall were not very productive in the reign of John. That king was Earl of Cornwall, and according to one or two historians he bestowed some valuable privileges on the county —relieved it from the operations of the arbitrary forest laws, and granted a charter to the tinners. A still more favourable

charter was granted to them by Edward I., under which the miners were exempt from all jurisdiction except that of the Stannary Courts, save in cases affecting land, life, and limb. The tinners agreed to pay to the grantor ½d. on every pound weight of wrought ore. Then, the labouring tinner who might discover tin in waste or uncultivated lands became entitled to a certain interest in such land upon giving proper notice in the Stannary Court to its proprietor. The laws and privileges of the Cornish mines were further enlarged in the reign of Edward III., and subsequent Acts passed during the sovereignty of Richard II. and Edward IV. confirmed them. Blackstone says, "The Stannary Courts of Devonshire and Cornwall for the administration of justice among the tinners therein are also Courts of record." These records, which exist in great numbers among the rolls of the Exchequer, record the usage of five centuries. The Stannary Parliament in Cornwall, which enacted laws for the government of the stannaries, consisted of twenty-four members. This Assembly elected its Speaker and proceeded regularly with its business when meetings were necessary. It was also known by the name of "Convocation." Tonkin asserts that the charter of Henry VII. first regularly established the Cornish Convocation.

Camden, in his "Britannia," writing on the Cornish mines, says, "After the coming-in of the Normans the Earls of Cornwall had vast revenues from those mines, especially Richard, brother to Henry III. And no wonder, when Europe was not supplied with tin from any other place, for, as for the mines in Spain, the incursions of the Moors had shut them up; and the veins of tin in Germany were not then discovered, nor opened before the year of Christ 1240, at which time (as a writer of that age has it) 'the metal called tin was found in Germany (by a certain Cornishman who was banished his country) to the great damage of Richard, Earl of Cornwall.'" Further, Camden says, "The Dukes of Cornwall, according to ancient custom, are to have forty shillings as tribute for every thousand pounds of tin; and it is provided that whatever tin is made it shall be carried to one of the four [now five] towns appointed for that purpose, where, twice every year, it is weighed and stamped and the impost paid; and before that no man may sell or convey it away without being liable to a severe fine" (*l.c.*, vol. i., pp. 143, 145).

Referring to the historical fact of the Phœnicians trading for tin with the ancient Britons, already intimated, I may also bring before you what the early historians have left on record concerning this primitive commercial transaction. The first notice is by the celebrated Greek historian Herodotus, who lived 450 years B.C., and who has been justly termed "the

Father of History." In writing of the natural productions of Europe he says, "Of that part of Europe nearest to the west I am not able to speak with decision. Neither am I better acquainted with the islands called the Cassiterides, from which we are said to have our tin. I have endeavoured, but without success, to meet with some one who, from ocular observation, might describe to me the sea which lies in that part of Europe. It is nevertheless certain that both our tin and our amber are brought from those extreme regions" (*lib.* iii., "Thalia," ch. cxv.) Scanty as this information is, yet you will have noticed its charming careful simplicity, which is also the more pleasing seeing that of late years much of what Herodotus had written concerning little-known and distant countries, and which had been called in question, has since proved to be in the main correct.

The second notice is by the historian Diodorus Siculus, who flourished about 50 B.C. Diodorus says, "The Britons who lived in those parts, digging tin out of a rocky sort of ground, carried it in carts at low water to certain neighbouring islands, and thence the merchants transported it into Gaul"; and, again, he pleasingly observes, "The inhabitants thereof, by conversation with merchants trading thither for tin, became remarkably courteous to strangers." Here I may also fittingly quote a nice observation respecting our Mother-country made at a very early date by another historian, Dionysius of Halicarnassus, who was famed for his caution and fidelity in his histories, and who lived about 30 B.C. Dionysius, in his "Periegesis," says "that no other islands whatever can claim equality with those of Britain."

The third record concerning Britain and its tin is found in the work of the celebrated Roman geographer Strabo, who flourished in the age of Augustus and Tiberius, and who died in the year 25 A.D. Strabo says, "The Cassiterides (from the Greek word *kassiteros* = tin) are ten in number, lying near each other in the Atlantic Ocean, towards the north from the haven of the Artabri"* (*lib.* iii.).

The fourth mention of the subject is by the great Roman historian and naturalist Pliny, who lived in the first century of our Christian era, and who lost his life in that terrible eruption of Vesuvius that destroyed the towns of Herculaneum and Pompeii, on the 24th August, 79 A.D., while too closely and fearlessly engaged in investigating that grand phenomenon of nature, as is graphically written by his nephew, Pliny the Younger, in his letters describing it to his friend Tacitus, the historian. Pliny, the elder, writes, "Opposite to this coast is the island called Britannia, so

* Lusitania and Cape Finisterre.

celebrated in the records of Greece and of our own country. It is situated in the north-west, and, with a large tract of intervening sea, lies opposite to Germany, Gaul, and Spain, by far the greater part of Europe. Its former name was Albion, but at a later period all the islands, of which we shall just now briefly make mention, were included under the name of Britanniæ. . . . Timæus,* the historian, says that an island called Mictis is within six days' sail of Britanniæ, in which white-lead† is found, and that the Britons sail over to it in boats of osier covered with sewed hides" (*lib.* iv., ch. xxx.). Further on Pliny writes, "Midacritus was the first who brought tin from the island called Cassiteris. . . . Danais was the first who passed over in a ship from Egypt to Greece. Before his time they used to sail on rafts. Even at the present day they are made in the British Ocean of wicker-work covered with hides" (*lib.* vii., ch. lvii.).

There appears some confusion here in the geography, which is not to be wondered at, for the Greek and Roman geographers, borrowing their knowledge from the Phœnician merchants, seem to have a very indistinct notion of the precise locality of those islands. It is not unlikely that Cornwall itself, or a part of it, or even small islands then existing in Mount's Bay and elsewhere, is meant, particularly in the relation of Timæus, and also in that of Diodorus; even St. Michael's Mount, in Mount's Bay (now and for some time past a shipping port with a quay), has been by some modern writers supposed to be the island referred to, whence the tin was taken by the Britons in carts, that island being easily accessible for carts, &c., at low water and at half-tides. There is an old tradition there in the west of Cornwall that a large portion of the south-west coast in Mount's Bay, &c., was early submerged and lost in a grand inroad of the ocean. A portion of the bay near the west side, about a mile from the shore, where ships frequently anchor, is always called "the Lake," and "Gwavas Lake," and I myself have seen, on the low flat sandy beach near Marazion and the Mount, at low water (the tide receding largely there), many upright stumps of large trees imbedded in the sand and mud.

Camden has some statements and observations on this particular subject, and I may again briefly quote from him. He says, "The inhabitants of the west end of Cornwall are of opinion that the promontory of the Land's End did once reach farther to the west. The neighbours will tell you,

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* Timæus, an historian of Sicily, who flourished 262 B.C. All his works are lost.

† White-lead = *Plumbum album;* the Latin word *stannum* denoted originally a compound of silver and lead, and was not used to denote tin until the fourth century.

from a certain old tradition, that the land then drowned by the incursion of the sea was called 'Lionesse.'" Here follow several reasons, or "hints," as Camden calls them, "contributing something of probability"; and he closes with the following remark: "To these we may add a tradition that, at the time of the inundation supposed here, Trevelyan swam from thence, and in memory thereof bears gules an horse argent issuing out of the sea proper" (*l.c.*, p. 148). This last remark is a very suitable one for Camden to make, he being Clarencieux King-at-Arms. I have myself heard of the tract of land overflowed by the sea being called Lionesse, and also know of large portions of land extending along the shore in the western part of the bay, once covered with delightful green turf (on which I had often walked and played), being entirely carried away by the sea.

I have mentioned a modern belief that St. Michael's Mount is (at least) one of the places in Britain anciently resorted to by the Phœnicians for tin, but I do not agree therewith. No doubt it has at present a kind of raised flat and broad beach, or natural causeway, connecting it with the mainland, passable for carts, &c., at and near low water, but whether such existed in those ancient times is highly questionable. And this, moreover, is largely supported by the Cornish name of the mount (Carregluzenkuz = "the hoar-rock in the wood"), and we know from our own ancient history that Cornwall was largely disforested in the reign of King John. William of Worcester records a tradition that "St. Michael's Mount was originally enclosed with a very thick wood, distant six miles from the ocean." The ancient Britons, workers of and traders in tin, must have had a long way to bring their heavy metal ore to such a mart or port, seeing that all old ancient workings have been found at a great distance from the mount. I should rather incline to believe that the Looe Pool, in Mount's Bay (only a few miles east from the mount), was then both open (without its bar of sand at its mouth) and, with the Cober River at its head, formed more of a harbour than it is at present, and quite sufficient for the light Phœnician vessels; and that Helford River and Harbour, on the east side of the Lizard Promontory (its head-waters at Gweek being only a short distance—three or four miles—across the same from the Looe Pool), was also another port visited by the Phœnicians. There are good antiquarian reasons for believing this, some of which I will briefly mention: (1.) Many ancient stream-tin workings have been discovered at and around those two places, with the rude implements then used in the extraction and dressing of tin. (2.) Various foreign remains have also been found there, as urns, coins, beads, &c., of Roman and other nations; and

on the Helford River are the ruins of large Roman encampments and towns. (3.) The ancient name of that country—the Lizard Promontory—is a very peculiar one—Meneâge, said to have been given to it by the Phœnicians, and to mean, in their language, a low heath-like plant with which that district abounds.* Certain it is that the name is not English, nor Cornish, nor Norman-French, nor Saxon, and it is still the common and legal name of the whole district; while several other names of places around the coast are also of foreign origin—some are said to be Persian. (4.) The principal tin, or "coinage," town in Cornwall, according to ancient English laws and charters, was Helston, which town is only a short distance from the Cober River.

I have said that Cornwall is rocky, and that granite is the chief stone; but there are many other stones and minerals to be found. The granite which forms the great bulk of the westernmost portion of the peninsula is succeeded by a series of very curious stratified rocks, which are generally slaty, but in certain bands assume the characters of a hornblende schist, of serpentinous rock, or of singular alternations of folia, in which garnet and its massive variety—allochroite, axinite, chlorite, and other silicates—play a prominent part. It is these variously coloured and angular, or even jagged, rocks that lend so wild and picturesque a character to the whole range of coast from Cape Cornwall to Pendeen Point, which includes Botallack and Levant; and again we meet these same stratified and ambiguous masses when, after descending through the deep shafts hewn out of the solid granite, we enter the levels or galleries which have opened the way under the western ocean; and, at smaller or greater distances, according to the depth, encounter them again, extending to the farthest points, some half a mile from the shore, which have yet been attained.

The lodes or mineral veins themselves are notable for their deviation from the directions which are usual elsewhere in the west of England. They may be seen especially in Levant and Botallack Mines, as well as in others near. They have a tendency to strike north-west and south-east; at the same time they are intersected by cross-veins (the guides of the miners). Some of these veins are narrow strings, but running—a number of them—parallel, in a width of from 10 ft. to 20 ft., through a somewhat friable granite. The ordinary lodes are from 1 ft. to 3 ft. in breadth, though in Botallack and Levant they have been much larger. As

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* *Erica vagans* = Cornish heath, a highly ornamental little shrub, often grown in gardens, and only found here in Britain; is a native also of the south of Europe.

usual, they are often made up of quartz, and commonly in a number of successive crystalline plates or combs; but even here they often exhibit charming little crystals of dolomite, of specular iron-ore, of göthite, or of manganese spar. Tin-ore (cassiterite) is the substance which has most largely contributed to the wealth of this district; occurring principally where the lodes occur in the granite rock, it has been followed down from the open "coffins"* of our remote Cornish ancestors to a depth of 300 fathoms (1,800 ft.) from the surface.

While, however, certain of the veins, as the north lode of Levant (and those of Huel Cock, a mine adjacent), carry a good deal of yellow copper-ore along with iron and arsenical pyrites, enormous wealth has been obtained from the courses of vitreous copper-ore, the sulphide-of-copper glance, which, especially in Botallack and Levant, extended for a great length under the sea, and which ore was more or less continuous down to a depth of almost 200 fathoms. The occasional occurrence of native bismuth, of cobalt-ores, of silver, and the rare and costly ores of uranium, add much interest to the mineralogical contents of these lodes.

Dolcoath Mine is mentioned at the beginning of my paper. This mine is situated near Camborne, and has long been the premier mine in Cornwall. However, after several years of continued unexampled prosperity, the mine is now worked only at a great loss, the loss on the last three months being nearly £6,000 (the total expenditure for the last quarter being nearly £20,000), with no prospect of doing better without a fresh and large outlay required to sink a new perpendicular shaft that would cost from £3,000 to £4,000, and take two years to complete, which is absolutely necessary. Tin-ore is plentiful in the mine, which is still rich, but only found at great depths, some of the levels being 364 and 425 fathoms. To abandon the mine would mean great and absolute want for many hundreds of the population. One of the obstacles was the heavy amount of lords' dues, which should have been levied on a more equitable and sliding scale; while another was the unwillingness of the adventurers (or shareholders, many of whom lived in London) to respond to a call for a very heavy outlay—a capital of £90,000 being required. A third hindrance was the very low price of tin in the market, mainly owing to the large quantity of that metal imported from the Straits, where it is also plentiful, and can be worked cheaply. However, after several meetings of the shareholders matters seem to be in a fair way of arrangement, by forming the mine into a limited liability company of 300,000 shares, and by the

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* Miners' term for the surface streaming-pits.

lords' dues being more equitably assessed according to the profits. It is only by the hearty co-operation of all parties—lords (owners of the soil), adventurers, and working miners—that the industry can be carried on, which will now be done for the first time in mining in Cornwall under a limited liability company.

In writing this paper for you I have culled from a few available sources, works both old and new—from Camden's "Britannia" (a ponderous folio first published in 1586, and the fourth and corrected edition in 1722), a veritable literary mine of learning, to sundry small serials of the present year—in order the better to support my own views and observations, made more than half a century ago, with undoubted modern authorities, and by so doing make my paper the more varied and generally interesting.

Art. XXXVIII.—*Telegraph Cables.*

By C. J. Cooke.

[*Read before the Hawke's Bay Philosophical Institute.*]

The subject of telegraph cables is one of considerable interest to myself, as I spent some years in testing cables electrically, both during manufacture and the laying in South American waters and among some of the islands of the West Indies. Our subject divides itself into four branches—the history of submarine telegraphy, the manufacture of the cables, their laying, and their working.

I. History.

The electric telegraph dates from the year 1837, and for some years after only land-lines were in use. Some ten or twelve years later Faraday suggested the use of guttapercha as an insulator for submarine lines. This substance was unknown in Europe before 1843. Faraday's suggestion was acted on, and a telegraph cable was laid in 1850. This prompt recognition of the value of guttapercha adds another to the many instances on record of the benefits of scientific investigation to human progress. Guttapercha is a very suitable substance as an insulator for telegraph cables; it is tough, flexible, will stand a knock, a shake, or a strain, is thoroughly impervious to water, and is unacted upon by salt-water. Of the different materials used as insulators in various descriptions of electrical apparatus, some, as glass and porce-

lain, are too brittle for cable-work, others, as wood, are not impervious to water. Hence guttapercha and indiarubber are the only substances which have been used as insulators in telegraph cables.

The following extract from Cassells's "Technical Educator" may be in place here: "The first cable from Dover to Calais consisted of a wire coated with guttapercha, but this was so imperfect that it failed the following day. . . . In the cable which was laid the following year the conductor consisted of four copper wires, each of which was separately insulated by being covered with guttapercha. The wires were laid side by side, a little hemp being placed between them to prevent their chafing. Tarred hemp was then laid on so as to form a solid rope, and outside all, as a protection against external injury, there were galvanised-iron wires spirally wound. The cable when complete weighed about 7 tons per mile, and possessed very great strength. It was found to answer admirably, and has remained in working-order ever since."

Thus early in the history of cables—in the second year of their existence—we have all the essentials of the cable of to-day. Other cables soon followed this one from Dover to Calais, a total of two thousand five hundred miles having been laid by the end of 1857, and fifteen thousand miles before the end of 1863. In 1858 the first Atlantic cable from Ireland to Newfoundland, two thousand miles long, was laid, but in a very short time it ceased to work. There were several causes to which its non-success was attributed, but the principal one was the iron sheathing-wires not being strong enough. We have seen that the Dover and Calais cable weighed 7 tons per mile. The deep-sea part of this cable weighed only 1 ton per mile.

The year 1866 saw the successful laying of two Atlantic cables, since which time there has been permanent telegraphic communication between Europe and North America. Ten years later there were five cables crossing the North Atlantic, besides one from Lisbon to Brazil. South Africa was the last place of any importance to be connected by telegraph with Europe. The troubles in Zululand and the Transvaal previous to 1880 having shown the extreme necessity for it, it was at once arranged to lay a cable, that the South African colonies might have the advantage of the prompt communication which the telegraph affords, and which has become a necessity to all civilised communities.

II. THE MANUFACTURE OF CABLES.

There are four parts of a cable to be considered—(1) The wire that transmits the current, hence known as the conduc-

tor; (2) the covering to prevent the dissipation of the electricity, known as the insulator; (3) a padding of some soft substance, as jute; (4) the iron sheathing.

1. *The Conductor.*—This, of course, is the essential part, the other parts being subsidiary to it. In cables it is always made of copper, on account of the high conducting-power of that metal. Copper has been considered by many physicists to have the highest conducting-power for electricity of all known substances, though other physicists have thought silver to be slightly superior. The question is not one of any importance to the telegraph engineer, as the high price of the latter metal precludes its use. It is interesting, however, to observe that very carefully devised experiments in this matter have not been attended with uniform results. These discrepancies are easily accounted for by the difficulty of getting the metals absolutely pure. Alloys are usually of much greater resistance, not only than the mean of their constituents, but greater than of either constituent. A very small admixture of a second metal with one of high conductive power such as copper produces a very marked effect in the resistance, while a trace of a non-metallic body increases the resistance enormously. It is stated that the copper of commerce has six or seven times the resistance of the pure metal. Thus telegraphy has created a demand for pure copper. It has also done much to supply that demand, as the residue from batteries in which copper is reduced to the state of metal furnishes a copper very suitable for telegraphic purposes. It may be mentioned here that, while silver and copper have the highest conductivity for a given volume, aluminium has the highest for a given weight. The latter metal, therefore, may prove of service for some sorts of electrical communication, but it is not likely to be used for submarine cables. In the first place, the weight of the copper, varying from 100 lb. to 400 lb. per nautical mile, is only a fraction of the weight of the cable. In the next place, an aluminium conductor of less weight but of greater sectional area would require a greater amount of insulating material, and this, again, would require a greater amount of sheathing-wire.

Copper, then, as having practically the highest conductivity, or, in other words, the smallest resistance for its volume, and not being too dear in price, always forms the conductor. In ocean cables there is usually a strand of seven wires twisted together. This arrangement is considered better than one thick wire, in which a flaw involving fracture would render the cable useless till repaired. A fracture of one or more wires of the strand has no effect on the signalling, unless all the wires are broken in the same place. Joints are the weakest places, but there the precaution is always taken

to bind the copper strand round with a coil of thin wire fastened only at the ends. If a joint should break the thin wire will still convey the current. In spite of all precautions a rupture of the conductor inside the insulator does sometimes occur. The distance of such a break from either end is easily found by observing the amount of the static charge that part of the broken cable will furnish. Of course, the amount of static charge per mile is always known.

An unusual kind of fault came under my own notice during the laying of a cable in the West Indies from Santa Cruz to Porto Rico. The conductor was broken inside the insulator, which remained perfect, but the ends of the broken pieces were in loose contact. On testing the resistance of the conductor after laying, it was found to be about double of what it had been previously. This had no effect on the signals, so it was not discovered till the laying was completed. Such a fault is difficult of detection. There would always be the danger in such a case of the loose contact not being maintained, when the signals would suddenly cease. It was necessary to cut the cable in one or two places to localise the fault, and replace the faulty length by a good one. The fault was found some distance out at sea.

2. *The Insulator.*—Most telegraph cables are insulated with guttapercha. I have only had personal experience of those insulated with rubber; I propose therefore to confine my remarks to the latter substance as an insulator. Indiarubber, like guttapercha, is a gum that exudes from several tropical plants. The best rubber comes from the forests of the Amazon. The indiarubber-tree resembles the ash in appearance. On making holes in the bark a juice like milk comes out. This, on being dried and smoked, becomes the black solid we are familiar with. Though generally black, some of the pure rubber, especially that sold at artists' warehouses, is much lighter in parts, and occasionally approximates to its natural colour—white. The black colour is simply caused by smoke. One of our company in Brazil tried to secure some pure-white rubber by filling a bottle with juice and corking it. In a day or two, however, the cork was forced out of the bottle; some of the rubber, now solid, was also forced out, and stood some inches above the neck of the bottle. It had acquired a very disagreeable odour. We gather, then, that the smoking is a necessary process. Rubber is collected from a large part of the Amazon Valley from trees most of which are growing wild. Pieces as large as saucers and from $\frac{1}{2}$ in. to 1 in. thick are strung on a switch and conveyed in canoes to the main stream or the larger tributaries of the Amazon. River steamers then convey them to the seaport of Pará, where they are transhipped on to ocean-going vessels.

The insulator of a telegraph cable, whether rubber or guttapercha, must be carefully purified before use, as an admixture of impurities would seriously interfere with its insulating properties. In the case of guttapercha, indeed, that substance after purification is sometimes purposely mixed with other substances whereby its insulating-power is lessened, but which enables signalling to be carried on more quickly. After rubber has been purified it is stretched into long tapes. Great care is needed here, as the manipulation of it renders it highly electrical, and light bodies, such as feathers, are readily attracted by it. If some substance adheres which would become charred on subsequent heating, the insulation would be destroyed, as charcoal is a good conductor of electricity.

If rubber could be used as an insulator it would have a great advantage over guttapercha, in that for a cable of the same dimensions it would allow of quicker signalling, or, in other words, a cable as effective could be made with a smaller amount of material.

Rubber is sometimes vulcanized—that is, mixed with sulphur and the two substances melted together. This is the common grey-coloured rubber. The mixture of these two insulating bodies forms another valuable insulator. Pure indiarubber is not suitable for cables, as when immersed for any long period the sea-water softens it and destroys the insulation. Vulcanized rubber resists the action of sea-water, but the sulphur attacks the copper, forming copper-sulphide. A consideration of these facts produced what was known as Hooper's core, a copper-insulated rubber, which at one time threatened to rival the guttapercha-covered wire. In this the conductor was covered with pure rubber, while the outside of the core, which was exposed to the action of salt-water, was composed of vulcanized rubber. Between these two layers was a third, the composition of which was a trade secret. It was claimed that this layer prevented the sulphur of the outer layer from penetrating to the copper. I cannot learn that any rubber cables have been made for very many years. Previous to that time Hooper's core was used for cables in the Persian Gulf, on the coast of China, for a length of two or three thousand miles on the coast of Brazil, and for torpedo purposes in the neighbourhood of the fortifications of Portsmouth.

3. *The Jute Padding.*—This need not detain us. Its use is simply to prevent the outside sheathing from injuring the core.

4. *The Sheathing of Iron Wires.*—This consists of a number of iron or steel wires bound round with hemp, which are twisted spirally round the core. These wires are simply for the protection of the cable, and are not used in

any way for the transmission of the current. There would be little need for this sheathing if it could be insured that the cable should lie on a smooth bed in water sufficiently deep to be removed from the influence of tides and currents. Unfortunately for submarine cable enterprise, the bottom of the ocean is as diversified as the land-surface. There are hills and dales, mountains and rugged crags, against which the cable may chafe until it is destroyed. There are precipices and narrow ravines across which the cable lies supported from the two sides and not sinking to the bottom. In such a position it is more liable to injury. A cable was broken in the Persian Gulf by a whale getting its tail entangled in it, while near the mouth of the Amazon parts of the cable have been raised with fish-teeth sticking in them. All these things show the need of a cable being well protected.

That the iron sheathing is very efficacious is shown by the fact of comparatively few cables having ceased to work while the sheathing has remained intact, although the insulation in many cases has been far from perfect.

From time to time proposals come up for what are known as "light cables"—that is, cables in which the iron-wire sheathing is replaced by hemp or sheet copper—but experience does not serve to recommend them.

From what has been said it will be seen that cables are more liable to injury near the shore, hence those parts are enveloped in much stronger sheathing. Often a second or even a third spiral of stout wires is coiled on the part of the cable meant to be laid near the shore, each wire being covered with hemp and the whole passed into a bath of a preparation of tar as it is being coiled on the cable. The cable thus prepared is technically known as "shore end," the main part of the cable being known as "deep sea." From the time the insulator is placed on the copper the core is kept wet, and is stored in tanks, where it is covered with water. When the sheathing is put on the water penetrates it and reaches the insulator. This is found necessary, as otherwise chemical changes may cause heating and consequent destruction of the latter. It also insures the cable being stored under conditions similar to those when it is in actual use.

During the whole process of manufacture the cable is subjected to electrical tests—continuous tests, where the instruments are observed every few minutes, and special tests two or three times a day. The least flaw is thus discovered at once, its locality sought for, and the faulty piece cut out. During the manufacture of the "shore end" the tests are more rigid still, as the removal of a faulty piece in that part involves the labour of cutting through a number of stout iron wires and a great loss of material.

III. The Laying of the Cable.

Telegraph cables are vastly more expensive than land-lines, in their first cost, in their maintenance, and especially if a line needs to be duplicated. If a cable has to be duplicated an entirely new one must be manufactured and laid, while a second land-line can be insulated on the poles that carry the first line. It is the object, therefore, of the telegraph engineer, in connecting places separated by the ocean, to lay the cable where the sea is narrowest. Hence communication between England and the Continent of Europe was first made by the cable across the Strait of Dover. Hence, too, the first Atlantic cables were laid from Ireland to the east coast of Newfoundland, communication from thence to the United States and Canada being afforded nearly all the way by land-lines. The bed of the Atlantic between the points named is very suitable for cables, being very free from steep declivities and ravines, of a moderate depth, sufficiently deep for the cables not to be exposed to the violence of storms, and not excessively deep in case it is necessary to lift the cables for repairs. Accordingly this part of the bed of the ocean is known as "Telegraph Plateau."

About twenty years ago the Great Western Telegraph Company was formed to connect the United States with Europe by way of the West Indies, an entirely new route. After many hundreds of miles of cable had actually been manufactured for this route the company was induced to abandon the enterprise. The Anglo-American company who owned the existing Atlantic cables feared the effect of competition, and paid the Great Western Company a sum of money to take their cable to another part of the world. At that time Brazil was being connected with Europe by telegraph, a cable being laid from Lisbon to Pernambuco, the easternmost port of Brazil, in accordance with the principle I have mentioned of laying cables across the ocean where it is narrowest. But the example of North America in respect to the use of land telegraph-lines could not be followed in South America, where the circumstances are totally different. A tropical climate, with heavy rainfall, dense forest, where there are very few roads and very little settlement except near the river ports, necessitated telegraphic connection with the other large cities of South America being made by cable. Here, accordingly, the company resolved to transfer their cable, and so changed their title to the "Western and Brazilian Telegraph Company." The cables of this company, two thousand miles in length, and extending from Rio de Janeiro to the mouth of the Amazon, were manufactured and successfully laid by the company known as "Hooper's Telegraph Works

(Limited)," the proprietors of Hooper's core. Another company was formed to continue cable-communication southwards to Buenos Ayres, and a third company to continue it northward from the Amazon River to join the West Indian Company's telegraph system. The cable for the latter company was also made by Hooper's. The capital for all these enterprises was subscribed in England, not with altogether satisfactory results to those who invested their money, the twenty-pound shares of the Western and Brazilian Company being now quoted at £10 15s.

The firm that manufactured the cable for the second of the above companies was unfortunate enough to lose its cable-laying steamer in South American waters with a considerable length of the cable on board. More cable was manufactured, and shipped on to another steamer named the "La Plata." Still more unfortunately, this vessel was also wrecked by a dreadful storm in the English Channel, and all on board, including a number of electricians, the officers, and crew—two men only excepted—were drowned. This disaster was said to be due in great measure to the steamer having on deck some heavy machinery for raising the cable lost in the first vessel. The saving of two of the crew of the "La Plata" by a passing vessel after they had been some thirty-six hours in the rigging-top exposed to the rigours of a winter storm is one of the most romantic episodes in the saving of life from shipwreck.

About the same time a smaller steamer was sent out by the Hooper Company to lay about a hundred miles of the shore end and intermediate parts of the cable forming the northern end of the cables mentioned. The ocean is very shallow near that part of South America, hence the need of a great length of shore end.

This brings me to the actual laying of the cable, in which I was concerned. A week or two after the above occurrences the cable steamship "Hooper" set sail from London. This vessel, reckoned at the time almost the largest afloat next to the "Great Eastern," was built for the Hooper Company by a firm on the Tyne in the short space of ninety days. Instead of a hold she was fitted with three enormous cylindrical tanks, which reached from near the keel to 1 ft. above the deck. In laying ocean cables it often happens that a number of vessels carry portions of a cable, to be afterwards joined into one. In this case one large vessel carried about a dozen lengths of cable in her three tanks. There was nearly two thousand miles in all, to be laid in several different places. We left the Thames on the 14th December, 1874, and proceeded across the Atlantic Ocean to Cayenne. In this neighbourhood, quite out of sight of land, we found a large

buoy in the sea, and attached to it was the end of the cable laid by the "Hooper" on the previous voyage. We then proceeded up the coast, and found a similar buoy supporting an end of cable. This was the hundred miles of shore end which had been laid by the steamer which left London a few weeks before ourselves, and which we had spoken with off Cayenne. We anchored close by this buoy, hauled the end of the cable on board, joined it to a section two or three hundred miles long in one of our tanks, and proceeded to lay the latter section down the coast to Cayenne.

During the voyage out, as during manufacture, each length of the cable was subjected to one or two electrical tests daily, but during laying the cable was subjected to a very rigorous continuous test. In this way, if anything occurred to cause a flaw in the insulator, it would be discovered in a moment. At the same time an arrangement was made for a signal to be sent from the shore station at regular intervals of five minutes, to insure that there was no interruption of the copper conductor.

To prevent this latter test from interfering with the former the signals are sent by what is known as an "induced current." The cable is connected to a condenser at each end—that is, one condenser is at the shore station, the other in the testing-room on the ship. The cable, therefore, is completely insulated. It is charged by a battery of about a hundred cells, and the amount of loss of charge in a given time determines the state of its insulation. Whether charged or not, if contact is made between the shore battery and the condenser a momentary current is induced in the cable, which works an instrument in the testing-room on the ship. I wish to direct attention to this point, as I shall have occasion to refer to it again in speaking of the work of signalling through the cables. The condensers employed consist of a number of sheets of tinfoil separated by paper soaked in paraffin. The tinfoil projects at the end of the paper, one set, say numbers 1, 3, 5, &c., at one end, the other set, numbers 2, 4, 6, &c., at the other end. Each set is connected to a binding-screw on its own side of the condenser. In this way two large metallic surfaces separated by a thin dielectric are obtained, and one surface receiving the slightest charge induces a momentary current in the other surface, and in any conductor connected with it, though no current passes across the paraffin dielectric.

The actual laying the cable is simply letting it run out of the ship into the sea. As the ship goes on some of the cable is left behind. The running-out must be controlled by machinery to prevent it running out too fast, which would waste the material, as also to insure it being paid out fast enough, otherwise the ship might go on and the cable be

broken. This machinery is also used for lifting the cable when a fault occurs or repairs are necessary. In laying the cable passes up to the top of the tank, then above the deck, round the drum of the paying-out machine, and over a wheel at the stern. A dial attached to the machine shows the amount of strain on the cable.

We went on paying out cable day and night till we again reached the buoyed end of the cable near Cayenne. This cable-end was brought on board the ship; the last message was sent to the shore station, Demerara; the end of the cable was hauled up from the testing-room on to the deck and joined to the one just hauled up from the buoy, and our work in that part was completed.

Before treating on some points in connection with laying the next section it may be in place here to say something about the testing-room. On the "Hooper" this was placed in one of the triangular spaces left between two of the cylindrical cable-tanks and the side of the vessel. It was immediately below the main deck. In fitting up the necessary apparatus on board ship two things that do not trouble the land experimenter have to be taken into account—the rolling of the vessel, which would disturb the liquids of the battery, and the mass of iron of which the ship is made, which is acted on by the earth's magnetism in a different manner every time the ship changes its course. This affects the needles of the galvanometers. The invention of apparatus specially designed to overcome the difficulties here indicated is due to Sir William Thomson. Our batteries were of the form devised by that gentleman for testing the first Atlantic cable. With several modifications it is essentially a Daniell's battery—that is, the metals used are zinc and copper, the latter metal being immersed in a solution of sulphate of copper. For telegraphic purposes this battery is now made without any porous cell, the copper plate with the solution of sulphate of copper being at the bottom of the cell, and the zinc in a solution of sulphate of zinc at the top. As the former solution is the heavier it remains at the bottom, and the two do not mix. A further modification for use on board ship is to have the cell packed with sawdust, so that the metals, instead of being in liquids, are in a sort of paste, but still in the proper solutions. The top of each cell was covered with solid paraffin, which kept everything tight in its place, and prevented evaporation.

The use of sawdust is very effectual in preventing the solutions mixing, however much the ship may pitch and roll. It is stated in treatises that sawdust increases the internal resistance of the battery. This is of little importance in testing cables, but the resistance is much lessened by keeping the sawdust well moistened. We found some cells in which

the resistance amounted to 40 ohms, after they had been kept in use for some months, when no precautions had been taken to prevent evaporation. But precisely similar cells in which the sawdust was thoroughly moist had no higher resistance than 8 ohms.

The effect of the movements of the ship on the galvanometer needles was overcome by the invention of Thomson's marine galvanometer. This is a modification again of that gentleman's mirror galvanometer. The latter instrument is so sensitive that it will indicate a current if one simply presses separate fingers on the two terminals. I have also obtained a very sensible deflection on an ordinary instrument of this description by working a small frictional machine for a few minutes and collecting electricity from the air of the room. In this case, although the electricity generated is at a high potential, the current obtained from the air is naturally an extremely feeble one, but the mirror galvanometer is sufficiently sensitive to indicate a current flowing for some seconds, or even a minute or two. Everything possible is done to make this instrument sensitive. It is composed of coils consisting of thousands of turns of copper wire, and the magnetic intensity is reduced to a minimum by having several magnets, one-half the number having their north poles immediately over the south poles of the other half. But what more than anything else makes the instrument extremely sensitive is the employment of a small mirror attached to the magnets to reflect a beam of light on to a scale. This arrangement gives virtually a pointer of a foot or two in length, but absolutely without weight.

A similar course is followed with the marine galvanometer. The galvanic needles are rendered astatic in the same way; they are surrounded by coils containing thousands of turns of wire, and the deflection is shown by the movement of a beam of light. In the land instrument it is sufficient to suspend the mirror with the magnetic needles attached by a single fibre, and they are allowed to hang and swing freely, because the instrument can be kept in a vertical position. In the marine instrument the vertical position cannot be maintained on account of the ship pitching and rolling, and it is therefore necessary to use several fibres, and to attach them at the bottom as well as at the top. In this way a much stronger current is necessary to deflect the needles. Again, it is necessary to minimise the effect of the earth's and the ship's magnetism on the instrument, otherwise it would be more sensitive with the ship in one position than another, and it would fail to indicate the principal thing required of it—the real condition of the cable. For this purpose several powerful magnets are placed in the instrument, and the whole is

enclosed in a thick iron case. The desired end is thus attained, but with the effect of still further reducing the sensibility of the instrument.

The other instruments in our testing-room consisted of coils of fine wire of known resistances, enclosed in suitable cases, on which the resistance of the coils was marked. These resistance-coils were of an alloy of platinum and silver, being a substance whose electrical resistance does not vary so much as that of many metals with a difference of temperature. German is another alloy used for resistance-coils for the same reason. The resistance of the coils being known, and practically unaltered from day to day, the insulation resistance of the cables can at any time be compared with them; if this insulation resistance fall below a certain standard it is assumed there is a defective place in some part of the cable. The defect is accordingly searched for, and the faulty length cut out.

A voyage of some hundreds of miles from the Cayenne coast brought us to the Island of Trinidad, in the West Indies. Our next length of cable was to be laid from here five hundred miles northward to the Danish Island of Santa Cruz. On this occasion the whole length of the cable was laid from our ship, so that I had an opportunity of seeing the shore end landed. The place selected for the starting-point was a small cove on the northern shore of the island. At the head of this cove is a strip of sandy beach only some 20 yards long; everywhere else the sea washes up to the base of the steep forest-covered cliffs. A small structure of galvanised iron stood on the beach. This was to contain the electrical apparatus for testing the cable while being laid. Behind this hut a path led up the hills, by the side of which could be seen the poles and wires of the land telegraph-line that crosses the high lands of northern Trinidad, and was to link our line with the town of Port of Spain, the capital of the island. It was late in the afternoon when our great vessel reached the mouth of the cove. We immediately set to work. The ship's boats were got out, and a raft was made by fastening boards across two of the boats. The heavy shore-end cable was coiled out of one of the tanks on to this raft, leaving, however, one end on the ship joined to the main cable; the raft was towed to the shore, paying out cable as it went; the end of the cable was hauled on to the beach, a spare piece was cut off, leaving the proper length to be taken into the hut.

A fuller account of this place and the laying of this section of the cable was written by one of our electricians for the *Leisure Hour* in 1877, the article bearing the title of "Cable-laying in the Tropics." We were accompanied on

this part of the voyage by a British man-of-war, which was engaged in taking soundings for us. One of their midshipmen joined us at Trinidad to receive their signals and interpret them to our captain, I suppose on account of naval signals not being known in the merchant service. The sailors having returned to the ship, we proceeded on our voyage, paying out cable day and night as before.

On the second or third day the electrical staff reported a flaw in the cable. The captain called out, "Full speed astern." As soon as possible the paying-out was stopped, the cable was cut, and it was found the faulty piece had not left the ship. It took only an hour or two to cut out the faulty piece, join up, and go on as before.

This expeditious manner of dealing with faulty cables is only possible on steamers. In the early days of cable enterprise they endeavoured to use sailing-ships towed by steamers or tugs to lay cables. If our ship had been a sailing-vessel she could not have been stopped in time, and the faulty piece of cable must inevitably have left the ship. The result would have been considerable loss of time in hauling the cable up again from the bottom of the ocean. This incident, then, illustrates one of several reasons why sailing-ships are not now used in cable-laying.

In the course of a few days we came in sight of our destination, Santa Cruz. On arriving the ship anchored, and next morning the shore end was landed as at Trinidad. Here I left the "Hooper" to take charge of the shore station, as two other cables had to be laid from this island. We had a more comfortable structure to work in than had our fellow-electricians in Trinidad, as there was a good-sized stone hut erected on this beach.

This brings me to notice that the cable electrician at the shore station may have certain disagreeable experiences like most other people, though I have none of my own to chronicle. Some electricians, however, that we knew, who spent some months at a cable hut in a lonely place in southern Brazil, told us they used to fire off guns at night to intimidate the wild animals prowling about. The work of the shore electricians during cable-laying is to send five-minute signals to the ship, which insures that the copper wire has not been broken. They also have to hold themselves in readiness to receive any instructions from the ship, and, if necessary, to send any important message to the ship. They do not require to test the cable till the work of laying is finished.

No incident worth remark occurred while we were at Santa Cruz, except the rupture of the copper conductor mentioned in the first part of this paper. The manufacturing company is responsible for the cable for thirty days after the

completion of laying. We were instructed, however, to allow the telegraph company the use of the cable for that period if it were protected against lightning. No special precautions for this are required while the cable is on the ship or during laying, but in the practical working a new element of danger is introduced. It arises in this manner: The most convenient place for landing a cable is often at a considerable distance from a town in which the telegraph-office is situate, so the cable is continued by a land-line to the office. This land-line may be struck by lightning, when, if the charge of electricity conveyed by it were allowed to enter the cable, it would probably inflict considerable damage. The place where a land-line joins a cable is accordingly fitted with what is termed a lightning-guard. These guards are of two kinds. The first consists of a short length of thin wire inserted between the land-line and the cable; this is fused by the heat developed by any powerful charge such as produces lightning. The second kind consists of a brass plate in contact with the end of the land-line; this plate is insulated from a similar plate in contact with an earth-wire by a thin layer of some material such as paper soaked in melted paraffin. In the latter case a powerful charge of electricity ruptures the paper, and the lightning passes harmlessly to the ground. In either case the lightning is prevented from entering the cable.

I waited at Santa Cruz the thirty days. A representative of the telegraph company took another test of the cables. I, as representing the manufacturers, took final tests, and, all these tests being satisfactory, we left.

IV. THE WORKING OF THE CABLE.

The instruments used by the telegraph-cable companies for signalling on their submarine lines are usually of a different character from those used on land-lines. The principal reason for this is that guttapercha and rubber are only indifferent substitutes as dielectrics for the dielectric of land-lines —atmospheric air. The consequence is that the passage of the current is retarded, and especially on cables of considerable length.

Attempts have been made to discover the velocity of electricity, but very discordant results have been obtained, as retarding influences cannot be got rid of. On land-lines, however long they may be, the transmission of the current is practically instantaneous. On the Ireland–Newfoundland cables, on the other hand, two-tenths of a second must elapse after sending before a sufficient current arrives at the receiving-station to work the most delicate instrument. The longer the cable the less the speed of the current, which varies inversely as the square of the length, so that a cable twice the length of

another has only one-fourth the speed. Worse than this is the fact that when a current arrives it does so gradually: a small gradually increasing current is what is really received, so that with any rapid signalling the several signals run into one another, and a great difficulty is experienced in reading them. The reason of this retardation is twofold—first, a part of the charge enters the insulator; and, secondly, the cable being surrounded by water, which is a conductor of electricity, the current induces another current in the water near it, and these currents act on each other. The fraction of time named—two-tenths of a second—as requisite for the front part of a current to traverse the Atlantic is not to be looked on as inconsiderable in telegraphy. Expert telegraph clerks have succeeded in sending forty words a minute, while an automatic sender can send one hundred words in that time. Each word may be reckoned on an average to consist of five letters, and each letter of two signals, which would make four hundred signals a minute in the first case and one thousand a minute in the second case.

As at first only a small fraction of the current arrives at the distant end of the cable, it is obvious that very sensitive instruments—that is, those worked with very feeble currents—are most suitable for cable work. So it was that Sir William Thomson's invention of the mirror galvanometer made Atlantic telegraphy practicable. Hence, too, it is seen that such instruments as the Morse and the Sounder, which are in use at the present time in our telegraph-offices, are not suitable for long cables, they being far less sensitive than galvanometers. On the cable from Santa Cruz to St. Thomas, however, only some forty miles long, I obtained clearer signals with a Morse instrument than with a galvanometer. It is only where a cable is of considerable length that difficulties as to speed of working have to be taken into account. In a cable that can be just conveniently worked with a galvanometer, not a twelfth part of the signalling could be got through in the same time with a Morse instrument.

The use of the mirror galvanometer for cables is now superseded by that of another instrument known as the "siphon recorder." This, as its name implies, is a recording instrument, and, like the Morse, is an electro-magnetic one—that is to say, the current on arrival temporarily converts a piece of soft iron into a magnet, which attracts suitable apparatus, so that a mark is left on paper. Unlike the Morse, it is almost as sensitive to feeble currents as the mirror instrument. The invention of this instrument is also due to Sir William Thomson. The use of the siphon recorder necessitates the cable being fitted with a large condenser at each end similar to those used in laying cables. This arrangement

has the advantage that the induced current received is instantaneous instead of being a gradually increasing amount, as when no condenser is used.

There are other advantages arising from the use of condensers. They prevent earth currents from entering the cable. One part of the earth's surface may differ very considerably from another part in regard to the amount or potential of the electricity there. If these places are connected by a wire an electric current will traverse it. These currents sometimes interfere with the working of the telegraph where the line is not fitted with condensers. A faulty cable may be used for a long period by being insulated with condensers. If the fault is considerable enough to allow sea-water to penetrate to the copper, we have all the essentials of a galvanic cell—two metals (copper and the iron sheathing) in a saline solution. The effect is to corrode the copper, and thereby make the cable useless. When condensers are used the faulty cable may be permanently connected to the zinc pole of a battery at the shore station, whereby a negative current passes out at the fault. The water there is decomposed, hydrogen gas being evolved, and the cable is preserved from injury.

Ruptures of the cables across Cook Strait and the fitting of a cable-repairing ship by our Government remind us of the expense the proprietors of telegraph cables may be put to in keeping their lines in proper repair. On the whole, while our subject is of the keenest interest to the student and the scientist, the results of the various enterprises are often unsatisfactory to those who have invested their money. It has been proposed to lay a cable across the Pacific to unite these Australasian Colonies with British North America. I venture to think this most desirable in the interests of the British Empire as a whole.

ART. XXXIX.—*Have we the Remains of a Swimming Swan-like Moa?*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute.*]

IN *Nature*, published on the 8th April, 1897, at page 534, is a letter by Professor O. C. Marsh, of Yale University, New Haven, Connecticut, dated the 16th March. This communication is of great interest, especially to those who, like myself, take pleasure in searching the past history of those

wonderful birds the *Dinornidæ*, or moas. Professor Marsh claims to have been the first to notice and place on record the finding of the fossil remains of "a carnivorous swimming ostrich," which he named *Hesperornis regalis*.

In this paper I wish to draw the attention of our New Zealand scientists to the evident possibility that in this country, which was the last harbour or retreat of many distinct and peculiar varieties of those struthious birds (the moas), seemingly descendants of those escaped alive to the mountain regions of a large southern continent (now sunken below the ocean wave, carrying with it the records of ages of reptilian and avian life), there may exist records which, if available to human research, would assist man to work out the problem of the succession of animal life.

New Zealand was, as it were, the last great stronghold of the moa. There were many kinds, each differing in size, bulk, and the colour of the feathering, but each kind having the struthious or bipinnate feathering on certain parts of the body. This would lead us to infer that if at any time in the existence of life on our world—no matter if it be in a far country—there is proof that a swimming ostrich once lived and propagated its kind, then we may reasonably expect to meet with the signs of an aquatic moa in the land which was their latest place of refuge; for the moa lived almost down to the time of European occupation, and I have myself seen its bones lying on the surface of the ground in a fair state of preservation.

In New Zealand have been found the remains of a large bird having anserine characteristics, a bone from which was at first thought by Sir Richard Owen to be that of a new form of struthious bird, and of a genus "hitherto unknown to science," for which he proposed the name of *Cnemiornis calcitrans*.

Some two years ago, when looking through Tregear's "Maori-Polynesian Comparative Dictionary," I noticed the Maori word "*tarepo*," said to be "the name of *Cnemiornis calcitrans*, a bird probably now extinct." On looking up the meaning of "*calcitrans*" ("kicking with the heel," a truly moa-like way of treating an opponent), I began to think that this was a native word distinguishing one species of moa from its congeners; but, on referring to Sir Walter Buller's "New Zealand Birds" (page 26 of the introduction), I found the following: "Following this came the discovery by Sir James Hector of the remains of an extinct goose of very large if not gigantic proportions, and undoubtedly flightless. This proved to be the bird for a few detached bones of which Professor Owen [as mentioned already] proposed the name of *Cnemiornis calcitrans*. The first tolerably complete skeleton

of this anserine form, which was certainly contemporaneous with the colossal moas, was obtained by the Hon. Captain Fraser in the Earnscleugh Caves, and was afterwards presented by him to the British Museum."* Taking into consideration that Sir Richard Owen was clearly at first sight of opinion that the parts of this species which he had under examination showed moa-like peculiarities, and comparing this circumstance with Mr. Marsh's letter, we may, I think, safely infer the probability that *Cnemiornis* was a swimming, or swan-like, moa.

In the Chathams Mr. H. O. Forbes found "thousands of swan-bones" on the site which was pointed out as the spot where the Moriori in olden times killed and cooked the great bird poua. May not this bird have also been a swan-like moa? We are naturally surprised at the total extinction by primitive means of a bird having the sagacity and great powers of flight possessed by the swans. Moreover, Mr. Forbes had previously discovered the remains of a swan intermixed with moa-bones and shells, the refuse thrown by the occupants of a cave at Sumner towards the mouth of the cave after each primitive repast. I have felt surprise at not having heard further details or remarks by Mr. H. O. Forbes or others on these swan-like birds of New Zealand and the Chathams. No doubt we shall hear more about them soon, interest therein having been revived owing to the finding of this swan-like moa in America, actually "with the feathers in place" and of the true struthioid character.

Within the last thirty years or so the Australian black swan (*Cygnus atratus*) has been introduced into New Zealand, and it is increasing and spreading over the whole country wherever an expanse of water is found, even at Waikaremoana, "the lake of rippling water," in the so-called "King-country," which has only recently, by permission of the native owners, become accessible to the European. And now man, with the assistance of all the arts of gunnery and other devices, could not possibly exterminate the black swan in New Zealand. How, then, did the original inhabitants of this country exterminate the swan indigenous to the land? The swans are birds of the present time, and their tenure of existence is by no means "played out." I would suggest that the reason of the extinction of the swan-like birds of New Zealand will be found in their being flightless, and consequently they and their eggs were easily obtained by man, the ruthless destroyer.

* See also Trans. N.Z. Inst., vol. vi., p. 76, pls. x.–xiv.A, "On *Cnemiornis calcitrans*, Owen, showing its Affinity to the *Lamellirostrate natatores*," by James Hector, M.D., F.R.S.

Mr. John White, in his "Ancient History of the Maori," in describing how the Maori hunted the moa, according to their tradition thereon, tells us that warriors were stationed along the side of the paths leading through the scrub bushes armed with spears, and that the birds were then *driven from the lakes* and speared by those in ambush. We may well ask what the moa was doing, living at, or on, the big waters.

The name "*ta-repo*" would mean "one belonging to, or about, *repo* (the swamp)," a very suitable name for a swan-like moa. Mr. Tregear does not state his authority for connecting *tarepo* and *Cnemiornis calcitrans* together, which is to be regretted. Possibly the authority is to be found in one of the earlier volumes of the "Transactions of the New Zealand Institute."

The following is an extract from *Nature* of the 8th April, 1897, at page 534:—

"*The Affinities of* Hesperornis.

"In the autumn of 1870 I discovered in the Cretaceous formation of Western Kansas the remains of a very large swimming-bird, which in many respects is the most interesting member of the class found living or extinct. During the following year other specimens were obtained in the same region, and one of them—a nearly perfect skeleton—I named *Hesperornis regalis*.* . . . The results of this and other researches were brought together in 1880 in an illustrated monograph.†

"In the concluding chapters on *Hesperornis* I discussed the affinities of this genus based upon a careful study of all the known remains. Especial attention was devoted to the skull and scapular arch, which showed struthious features, and these were duly weighed against the more apparent characters of the hind limbs, that strongly resembled those of modern diving-birds, thus suggesting a near relationship to this group, of which *Colymbus* is the type.

"In summing up the case I decided in favour of the ostrich features and recorded this opinion as follows: 'The struthious characters seen in *Hesperornis* should probably be regarded as evidence of real affinity, and in this case *Hesperornis* would be essentially a carnivorous swimming ostrich.' ('Odontornithes,' page 114.)

"It is an interesting fact that this decision is now on record a quarter of a century after the discovery of *Hesperornis*, and a decade and a half after its biography was

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* *American Journal of Science*, vol. iii., p. 56, January, and p. 360, May, 1872.

† "Odontornithes: a Monograph of the Extinct Toothed Birds of North America," 34 plates, Washington, 1880.

written in the 'Odontornithes'; its true affinities, as recorded in that volume, are now confirmed beyond dispute. In the same region where the type specimen was discovered a remarkably perfect *Hesperornis*, with feathers in place, has been found, and these feathers are the typical plumage of the ostrich."*

Dr. R. W. Shufeldt has a letter in *Nature* of the 13th May, 1897, in which he attacks Professor Marsh's theory of the struthious affinities of *Hesperornis;* but in saying "that *Hesperornis* possessed some kind of a plumaceous plumage, however, I long believed, and see no reason to change that opinion now," Dr. Shufeldt has supported my contention that the poua and *Cnemiornis* carried a covering of feathers resembling those of the moa, and so had no powers of flight. Certain of the moas had a considerable portion of their feathers, especially those on the breast, well covered with a fine down, and this down would be greatly impervious to water and buoyant, owing to the air entangled therewith, and would not by any means be such an unsuitable protection to an aquatic bird.

To quote again from the same writer, "Professor Marsh is not the only writer that has been led astray in some parts of avian classification by employing what have been called 'struthious characters' in avian osteology, and now he thinks his views are supported by the recent discovery of Williston, referred to above. Having carefully examined the published plate of the latter author, I must say that I am quite sceptical as to what he believes to be long tarsal feathers (leg-feathering) in *Hesperornis*. Surely in the figure the resemblance to feathers is very remote; and, quite as surely, long drooping plumaceous feathers hanging down to the feet in a big powerful diver would in no way whatever assist it in either swimming or diving. . . . Plumaceous plumage was very likely far more prevalent among the earliest birds in time than it is now among modern types, and this applies absolutely to not a few characters in the skeleton. The latter, along whatever line we may trace them, are evidences of an approach reptilewards, and by no means point to struthionine affinity. Certain peculiarities of the pelvis and at the base of the cranium, when associated with certain others, have, as I say, been unfortunately termed 'struthious characters,' and, with this mistaken idea operative, our more superficial avian anatomists can see but little beyond 'ostrich' in either *Finamon* or *Apteryx*. . . . There is no more ostrich in *Hesperornis* than there is diver in *Struthio*."

* Williston, "Kansas University Quarterly," vol. v., 53.

Whether or no, Dr. Shufeldt would seem to be of the same opinion as myself—viz., that where you find birds of an early and primitive type it is reasonable to expect their feathers to resemble more or less those which we have found were carried by the moas. I would therefore warn collectors of so-called moa-feathers which may possibly be discovered at some future date to consider the claim of poua and *Cnemiornis* as likely one-time owners of somewhat similar feathers, and not to connect all such with the moas only.

Art. XL.—*Moa and Toa—the Bird and the Tree.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute.*]

In vol. xxv. of the "Transactions of the New Zealand Institute" Mr. Edward Tregear gives a very interesting paper on the etymology of the word "moa," which he maintains to be nothing more nor less than the Polynesian name for *Gallus domesticus*, the domestic fowl. That this bird, so useful to mankind, may be said to be the bird *par excellence* of the Britisher we must all allow, for has it not, as time passed on, monopolized three main words in the English language—that of "fowl," or the bird, and the designation for male and female in those of "cock" and "hen"?* That the fowl has also proved as great a boon to the inhabitants of Polynesia I do not doubt, but I am of opinion that first a large struthious bird was known to the people of Polynesia under the name "moa," possibly before these people came to the further isles of the Pacific, and that after having left the lands where these great birds were found some of the Polynesians became possessed of the domestic fowl, and gave the now traditional word "moa" to their new acquisition. But the time when the fowl was brought to the islands was some time after the Maori came to New Zealand, and the Maori was totally unacquainted with *Gallus domesticus*.

When the Maori of the later migrations reached New Zealand they found various large struthious birds still living in that country, but which were almost exterminated by another

* Captain Cook brought the fowl to New Zealand, say, fifty years before the pakeha missionary questioned the Maori as to the name for the large bones found lying about, and the answer was, "They belong to the moa, and those gizzard-stones are moamoa." Is the hen also called "moa"? for we see that word was not forgotten; and why not?

and older branch of the Polynesian race long resident in New Zealand. These people, or some of them, were Morioris, akin to those first found in the Chatham Islands. These large birds were already known by the name of "moa," the same name by which the ancestors of the Polynesian had known the cassowary and emu in other lands.

In some of "the islands" *Gallus domesticus* is called "moa," while at other places its name is "toa," but whether the two words are variants one of the other I find no evidence. "Toa" is also a warrior or fighting-man, and, as fighting is one of the chief characteristics of the domestic cock, the name may be considered applicable to that bird; but this may be a mere coincidence.

In Maori language we have the verbal form *whaka toa moa*, "to perform a derisive dance in presence of the enemy." The literal translation of this is "to make to do, the warrior, of the moa," or "to do as the dancing moa," for "toa" also means "to romp or gambol."

I have somewhere read of the ostrich at times indulging in a kind of dance with one or more of its companions, but forget my authority for this statement. At the same time we must allow that the domestic cock makes considerable demonstration on approaching an antagonist, such as advancing sideways and every now and again picking up imaginary food or pebbles, bits of stick or straw, and what in colonial expression is "putting on side" and "bounce." But this can hardly be considered as any kind of dance. At many islands—Samoa, for instance—the word "toa" is a fowl,* but it also means the ironwood-tree (*Casuarina equisetifolia*). Why the fowl and the tree should be of the one name is remarkable, and worthy of consideration.

Some thirty years ago I went over to Australia to hunt up a witness in a law case. When travelling in that country I was greatly struck by the beautiful and extremely graceful habit of growth in the so-called "she-oak" (*Casuarina*). This tree had nothing resembling the leaves of ordinary trees, but long, thin, flexible, succulent, drooping, twig-like foliage, which at once recalled to memory the long streamers of the water-weed which I knew years ago in England's streams by the name of "mares' tails." The foliage of the Australian "she-oak" gives a more even and graceful rounded droop than that of our weeping willow, which is such a striking feature in the "improved" landscape of our adopted country. In Australia

* I am informed by Mr. W. G. Ball, for some years resident in Samoa, that "toa" in Samoan means "cock," and also "warrior"; "moa," besides being the general word for fowl, also means—(1) The end of a bunch of bananas; (2) fleshy part of mollusc; (3) child's top; (4) epigastric region; (5) the middle (of a road or river).

I also saw a tree of the same species called the "he-oak." This was of fastigiate habit, and without the graceful outline of the "she-oak."

On reading the diary of Sir Joseph Banks, who accompanied Captain Cook on his first voyage, I saw mention of the tree "toa," and took notice of its scientific name of *Casuarina equisetifolia*, and saw an apparent connection between the names "*Casuarius*," the bird cassowary, and "*Casuarina*," the tree.

When we note the exquisite slender droop of the foliage of the "she-oak" and then compare with it the rounded flexible droop of the plumage of the emu, especially when the head and neck of the bird is hidden or stooped in feeding, the resemblance between the bird and the tree is apparent.

I am told that the word "casuarina" was adopted most probably by the Dutch as the scientific cognomen of these trees in the eighteenth century; and I firmly believe that when the Dutch (or those who first named the tree) thus took their cue from the natives of the country where both the bird and the tree were found the natives had previously named the bird and the tree as somewhat resembling each other.

"Cassowary" is said to be a corruption of "suwarri," and this word should be searched for among the peoples of the Malay Archipelago by those interested in this study.

One of the members of our Institute has kindly supplied me with the following extract from Webster's "International Dictionary," 1894:—

"CASUARINA.—[Supposed to be named from the resemblance of the twigs to the feathers of the cassowary, of the genus *Casuarius*.] (*Bot.*) A genus of leafless trees or shrubs, with drooping branchlets of a rushlike appearance, mostly natives of Australia. Some of them are large, producing hard and heavy timber of excellent quality, called 'beefwood' from its colour."

Sir Joseph Banks tells us that at various islands visited by him the "e-toa" (or, as he writes it, making the article *e*—Maori *he*—a part of the name "etoa") is the tree from which the natives make their fighting weapons—clubs, pikes, spears, &c.—and also the peculiar beater used by the women in making tappa clothing.

The Rev. W. Wyatt Gill also gives numerous instances of the usefulness and durability of its wood and of the gracefulness of the tree itself; but as no reference is made to the pendulous habit seen in the "she-oak" I feel certain that *C. equisetifolia* is of an upright growth. Still, in Borneo or Papua, which are nearer to the mainland of Australia, the "she-oak" may likely be found, and there we find the casso-

wary also. Mr. Gill points out that the toa-tree is found on the volcanic islands, and not seemingly on the coralline islands. This would seem evidence that the people who used weapons of toa wood could also obtain volcanic stone for weapons and tools. This gentleman says of the Island of Atiu, "We sailed nearly round the island to the landing-place. Everywhere near the sea grew the tall graceful *Casuarina equisetifolia*, closely allied to the 'she-oak' of Australia, and which alone furnished the weapons of war in the olden time."

I have remarked on the European water-weed ("mares' tails"), and now draw attention to the descriptive word for the "toa," which means "foliage resembling the long coarse hair of the horse." May not the aboriginal also have noted a likeness to the hairy feathers of some struthious bird?

The Maori has a plant-name "rau-moa," or "leaf moa" (*Spinifex hirsutus; hirsutus*, hairy). Why so named if not after the hair-like plumage of the bird moa.

ART. XLI.—*About the Native Names for Places.*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute.*]

THE Maori of New Zealand having left us no written records, it is a very difficult matter to collect fairly reliable evidence of the past history of this people. Certain old legends, songs, and tribal pedigrees have been collected and written down by a few of the early colonists, and these scanty contributions are all we are likely to obtain, unless some new method of gaining information be started and followed up successfully.

A useful study may possibly be in the collecting and analysing the original names of places, rivers, or localities, as a means of obtaining some insight into the thoughts of those from whom such names originated. In this paper I will endeavour to show that we still may find a part of the history of the Maori people in local names.

Take, for instance, the three names Tautane, near Cape Turnagain; Manawatu, the name of a large river and district; and Ruahine, the central mountain-range of the Northern Island of New Zealand. These names are found within a radius of some forty miles, and at first sight would seem to have no connection one with the other; yet, by the light of an old custom among the Maoris, it is evident that all three

names originate from the different operations of the one ceremony. A fourth name, Whangaihau, is also connected with the above, and is, I think, to be found in the altered name Wangaehu, near Cape Turnagain. It would seem reasonable to expect that all the names pertaining to the ceremonies above referred to should be found in use, rather than that three should be found and one absent.

Dr. Shortland, in "Traditions and Superstitions of the New-Zealanders," published in 1854, page 247, gives, "Tarapipipi's Narrative" on customs of warfare, from which I quote as follows:—

"Of the slain, some are cooked and eaten. The first man killed is made sacred to the *Atua* ('Spirit' or 'God') in order to propitiate him. He is called the *mata-ati*, and is thus disposed of: His heart (*manawa*) is immediately cut out and stuck on the top of a post (*tu*) = Manawatu. His ear and some of the hair of his head are preserved to be used at the ceremony called *whangai-hau* ('feed-wind'). The ear is for the female *ariki* of the tribe to eat in the ceremony called *rua-hine* (old woman), by which the war-party are made *noa* (made common, not under *tapu* or other restriction). The heart is for the male *ariki* to eat at the ceremony called *tautane*. The second person slain, called *mata-tohunga*, is also sacred, the priest (*tohunga*) alone being permitted to eat of his flesh. When the war-party return to their own settlement they perform the ceremony of *whangaihau*, after which they are *noa*, and are at liberty to go about their ordinary business. As for the remains of the flesh which the war-party had been eating, it is thrown away in the bush, for it must not be eaten by women. Such food is sacred; the males alone may taste it. If any of it were eaten by a woman some misfortune would happen to the tribe."

Of the cannibalistic habits of the Maori we have proof, therefore, in the place-names Manawa-tu ("heart standing up"), Rua-hine ("old woman"), Tau-tane (*tane*, "a male," probably the oldest chief of the tribe, or male *ariki*), and Kai-tangata ("eat-man"), near Dunedin, in the South Island.

The ceremony performed after the birth of a child also includes the names Tautane and Ruahine, described by Shortland thus: "The infant comes into the world an exceedingly sacred object, and must be touched by none but the sacred few present till the *tapu*, or restriction, has been removed. The ceremony attending the removal of *tapu* from a child is as follows: A small sacred fire being kindled by itself, the father takes some fern-root and roasts it thereon. The food so prepared is called *horohoronga*. He then places the child in his arms, and, after touching the head, back, and different parts of its body with the *horohoronga*, he eats. This act is

termed *kai-katoa i te tama-iti* ('eating the child all over'), and is the conclusion of the ceremony performed by the father. The sacred restriction, however, is not yet completely removed from the infant, but nothing more can be done till the following morning, when, at daylight, the child's eldest relative in the direct female line cooks fern-root over a sacred fire, precisely in the manner the father had done, and, having similarly touched the head and various parts of the body of the infant with this dressed food, afterwards swallows it."

The part of the ceremony performed by the female is called *rua-hine* ("old woman"), and when it is ended the infant is quite *noa*, or free from restriction, and may be handed about among the persons standing by, to be danced in their arms. The ceremony performed by the father is called *tautane* or *tamatane*, and at its conclusion the child receives its name.

One of our volcanic mountains is named Rua-pehu, or "the blow-hole," a most appropriate name. A stream which takes its rise on this mountain is named Wanga-ehu, or "the bay, or canoe-landing, having muddy waters." This latter name is similar to the one on the East Coast, which I hinted might be corrupted from the original Whangaihau. A stream may be known by the same name as the bay where it flows into the sea, and the West Coast Wanga-ehu is evidently correctly named, as the following extract from the *Hawke's Bay Herald* will show :—

"With reference to our articles on the outbreak of Ruapehu, a Moa-whango" ("hoarse-voiced moa") "resident writes : 'There was also another outburst some years after Tara-wera'" ("hot peak"), "'when an overflow from the hot lake took place, and, by melting the snow, caused a big fresh in the Wanga-ehu. . . . I sent down a bottle of the Wanga-ehu water a few days afterwards, showing how largely it was charged with minerals. The Wanga-ehu is always affected by any extra volcanic energy on the part of Ruapehu. On Sunday, the 10th March last [1895], when a great outburst of steam occurred, which was noticed from different parts of the Island, a shepherd whom I know well was close by the mountain, and simultaneously with a tremor of the earth and the rising of a column of steam from the summit there were several small vent-holes which threw out earth, rock, and steam, accompanied by a loud whistling sound. These vents are on the eastern side of the mountain, about parallel with the course of the Wanga-ehu.'" Probably these vent-holes give the name Rua-pehu, or "the blow-hole," to the mountain.

To compare with Wanga-ehu we have Wanga-nui ("big

bay"), the name of a landing-place and also of the river emptying therein. Whanga-ra, on the east coast of the North Island, is said by one writer to be so named because the Maoris on arriving there were reminded of a similar place in the land from which they had migrated. But its position gives proof of the origin of the name "east bay," or "bay facing the rising sun" (*ra*, "the sun," also "the east"), and there is no more necessity to assume it was so named from any fancied resemblance to any other place than to suppose East Cape was for a similar reason so named by Captain Cook.

Whanga-paraoa is by tradition said to be so named because the voyagers in the "Arawa" canoe found a certain kind of whale stranded on the beach when they arrived, and a quarrel occurred with the crew of the "Tainui" as to which were the rightful owners of this waif from the sea.

Whanga is often written as Wanga, and is accepted as correct in either form, according to the spelling originally used to denote any particular place; and I believe the Maoris of certain districts are in the habit of omitting to sound the *h* in several other words also.

In the names of places and streams we often find the compound word *wai*, "water," as in Wai-nui, "big water," a very common name (the Wainui of Hawke's Bay is now known as Herbertville, named after the first pakeha who built a house and lived there); Wai-paoa and Wai-pawa, "smoky water," some say in allusion to the misty vapour arising from the water of the river during certain conditions of the atmosphere; Wai-pukurau,* "the water near which grows the edible fungus or mushroom"; Wai-tangi, "the water where the crying or wake was held" (this, you will remember, is the place where the celebrated treaty or compact was signed between the early settlers and the Maori, and the name Waitangi has become historical thereby); Wairarapa, "rippling water"; Wai-makariri, "the cold water."

Awa, "a river," is also used in place-names, as Awa-nui, "large river"; Awa-tapu, "river made sacred"; Awa-kino, "the river of misfortune or evil"; Awa-huri, "the rolling-over river" (perhaps of whirlpools).

Ara, "a road or track," as Ara-tapu, "the forbidden road": At times a renowned chief, when desirous of protecting the people of a neighbouring pa or fortified village from the

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* In the *Otago Witness* a sale of sheep is mentioned, by Mr. D. Murray, of Puke-rau (no doubt a mistake for Puku-rau), literally "the mound-leaf," or "swelling leaf," a mushroom, or fuzz-ball (*Lycoperdon fontanesei*).

hostility or revengeful attack of his allies, would claim that the road leading in that direction was *iwi-tua-roa* (his backbone or spinal column), after which assertion any hostile party who went by that road or *ara-tapu* would incur the penalty of a reckoning with the protecting chief. But, owing to the Maori greatly fearing any sort of *tapu*, there was little risk of any authorised form of *tapu* being broken.

Puke, "a hill," gives the folowing place-names: Puke-tapu, near Napier, "the sacred hill"; Puke-kohe, "the hill where grows the kohe-tree (*Dysoxylum spectabile*); Puke-atua, "of the Spirit (or God)."

Maunga, "a mountain," from which comes Maunga-tu-roto (probably short for *tu-roto-waenga*, "standing within, or in the midst or middle of, or near, a lake"): This may be a hill surrounded by a plain, or a hill between two other hills. Maunga-tua, "a mountain with a ridged top," south of Dunedin.

Manga, "a branch stream," gives Manga-one, "the stream of the sand or of earthy water"; Manga-rangiora, "the stream of the rangiora shrub" (also called wairangi, a shrub sometimes eaten by cattle, but said to be poisonous to the horse); Manga-kuri, "the stream of the dog." This word is often shortened to "Ma," as Ma-harahara, "the small stream"; also Ma-kuri, "of the dog"; Ma-karetu, "of the sweet-smelling twitch-like grass" (*Hierochloe redolens*).

Pa, "a fenced village (or fort)," gives Pa-toka, "the fort on the rock"; Pa-i-kaka-riki, "the village of the green parrot" (*i.e.*, parrakeet), on the Wellington–Manawatu Railway-line; Pa-karaka, of a small fruit-bearing tree (*Corynocarpus lævigata*); Pa-kowhai, of a tree (*Sophora tetraptera*).

Of miscellaneous names are Kiri-kiri, "the place where gravel or small water-worn stones are abundant"; Kiri-paka, "the place of the flint-stone"; Kai-kora, "little to eat," or "fragments of food"; Kai-koura, "the feast of crayfish."

Kai-manawa, the name of a range of mountains ("eat heart"): This name may have the same origin as Manawa-tu, described previously. [Note: Manawa-nui = patience; as Bunyan says in "The Pilgrim's Progress," "Keep a good heart, Mr. So-and-so."]

Tara-rua (Mountains) may mean, "having two peaks or cones." A noted chief of olden times was named Tara, and, according to the Rev. W. Colenso, the Te Aute Lake was called, after him, "Roto-a-tara," or "Tara Lake." Mr. Elsdon Best tells us that Wellington Harbour is also named Whanga-nui-o-tara, "the large bay of Tara." At the same time *tara* is the name for several kinds of seagulls, as *tara-nui*, *tara-iti*, &c. The latter writer also says that the chief Tara at one time occupied an extensive pa near the place we now name

Tara-dale. Previous to learning this I supposed Tara of the dale had some relation to "the harp which hung in Tara's halls." Can any of the members of our Institute explain the origin of the place-name Tara-dale?

Kaweka, a word meaning "a mountain-range." Poranga-hau, the name of an ancient pa, belonging to Tawheta, in Hawaiki.

Kuri-pa-pango, which you all have heard of, would seem a very singular name. I suppose it "the dog with the litter of black pups," the word "pa," in one sense, being "a litter of pups." Marae-kakaho, "a court (or yard) fenced round with toe reeds."* Tutae-kuri, Tutae-nui, Tutae-kara, are names having an unsavoury meaning; but at the same time let not such words be exchanged for inexpressive names of European origin, as has been the case elsewhere, for the original names of places aid us in following the history and the thoughts of the Maori people, whom we, in a measure, have robbed of their right of occupation. Why alter them? It is only the student who is likely to consider their original meaning.

Art. XLII.—*The Ceremony of* Rahui: *Part II.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute.*]

This paper is a further contribution to the study of the custom of *rahui* as practised among the Polynesian and other races of mankind so far as I am at present able to follow it. My first essay on this subject is published in the "Transactions of the New Zealand Institute," vol. xxviii., p. 54.

It is allowed by eminent ethnologists that the Polynesian peoples are a race composed of the blending of two or more types of mankind. We can trace the evidence of this even in the general appearance of Maori people taken as a whole. Some are of a fairly light complexion, tall, and having aquiline features; others, of a dark skin, and hair inclined to curl, are shorter in stature, but equally massive in build, and go to prove a blending with a negrito people; and occasionally a

* This *whaka-tauki*, or proverb, partly illustrates the name: *He ta-kakaho ka kitea, tena-he ta no te ngakau e kore e kitea* ("A crooked part of a stem of toetoe can be seen, but a crooked part in the heart cannot be seen"). Toetoe is a large grass, *Arundo conspicua.*

blonde type may be met with, having auburn hair. These last are by tradition said to be of superior dash and bravery in battle, and were called by the distinctive name of "*erukehu*." The *erukehu*, or white Maori, would seem to be the result of an occasional outcrop of the blood of a pure light-complexioned people who have at one time been absorbed, though not entirely lost, among the multitude of the two darker races of the Polynesian blend. To which of these original peoples we may look as the introducers of the custom of *rahui* there is as yet no sufficient evidence; but perhaps by careful research this may be traced or connected with the history of a people yet inhabiting one of the large continents.

The Moriori of the Chathams have less of the dark blood outcropping, yet are said to have shown occasional specimens of the *erukehu* type. To my thinking, they originally left New Zealand on the arrival of the "Arawa," "Tainui," and other canoes at this country, bringing the Maori—a fiercer and more turbulent people—a race of cannibals, who subdued or caused the migration of the milder-disposed Moriori. But although the Moriori people had less trace of negrito blood showing in their appearance, yet they give historical evidence of the use of the custom of *rahui*, as will be presently described in this paper.

Whether the occasional mention by travellers of albino Polynesians being seen refers to cases of true albinism or to the type *erukehu* we may well desire to obtain evidence upon. Sir Joseph Banks, in his diary, in describing the Tahitians, at page 128, says, "During our stay in these islands I saw some —not more than five or six—who were a total exception to all I have said above. They were whiter than we, but of a dead colour, like that of the nose of a white horse. Their eyes, hair, eyebrows, and beards were also white. They were universally short-sighted, and always looked unwholesome—the skin scurfy and scaly, and the eye often full of rheum. As no two of them had any connection with one another, I conclude that the difference of colour, &c., was totally accidental, and did not at all run in families." There is certainly no description of an *erukehu* here, but we may notice the evident mistake in calling the eyes "white" in colour.

Dr. Dieffenbach tells us of meeting an albino native in the Rotorua district, and Mr. John Harding, Mount Vernon, Waipukurau, tells me of one he saw in the early days of European settlement at Wellington. I also remember hearing of an albino native woman coming to Napier with other natives travelling from the north some twenty years ago, and suppose these are something quite distinct from the ruddy-haired *erukehu*, and of an abnormal type or occurrence.

Certain authorities on Maori tradition maintain that we find no mention of the occurrence of human sacrifice, but this position is not tenable. We are told by the late Rev. W. Wyatt Gill, in "Jottings from the Pacific," that by the kindred people of Rarotonga human sacrifice was made to the *atua* (deified ancestor) Rongo. Under the heading "Bible Truths illustrated" (by native teachers) is the account of the manner in which Itieve was enticed by a message from his relative Kekeia (thief) to meet him on the summit of the mountain Maungarua: "Whilst on the way thither Itieve was warned by the cry of the bird kaua (kingfisher)—a bird considered sacred to Tane—that there was a hidden foe in the vicinity, but Itieve replied, '*Ao, Tane; koe e karanga nei*' ('Aye, Tane; it is thou who art warning me'). The bird again gave its warning cry of 'kaua' (from which it is named), to which Itieve replied as previously, and recklessly went forward to the place of meeting. By this time his concealed foes had crept round through the fern and bush, enclosing him on every side. Kekeia, seeing that his prey was secure, arose and shouted, '*Taumoa, e Rongo, toou ika*' ('Rongo, seize thy prey'). At this preconcerted signal the armed men rose as if by magic out of the earth, and clave the skull of Itieve. A long spear was thrust through his body, and he who had despised the three-fold warning of the gods was carried off with shouts of triumph between two men to the gloomy cave of Ivirua, and there cooked and eaten."

Mr. Gill also tells us that it was customary after a battle, and to secure a lasting peace, for the victors to search about for a particular one of the vanquished party as a sacrifice to Rongo, as, for instance: "To secure peace two special sacrifices were made to the insatiable Rongo, as the supreme ruler of human destinies and the god of war [Tu is the god of war in New Zealand, Rongo of agriculture, especially of the *kumara*, or sweet potato—T.W.]. Both were young women. The first was Kete-ta-kiri, who was contemptuously designated '*ei ika aua na Papa*'—*i.e.*, 'fish refuse thrown to Papa,' the mythical mother of dread Rongo; the second (Taike) was to be '*ei ika akatangi pau*'—*i.e.*, 'a fish in order that the drum of peace might sound.'"

Usually one sacrifice was deemed sufficient, but Makaitaka decreed two: "The weeping aunt of Taike, seeing she could not save her, with the instinctive love and pride of native women, got her best petticoat and wrapt it round her. The unhappy girl was then dragged by one hand outside the oven-house (cooking-place). Her loud cries and bitter tears at her hard fate did not move Vaere's compassion. The armed men in ambush now left their post and rushed for-

ward for the honour of spearing the inoffensive girl, as the actual murderer obtained lands and distinction. Great care, however, was requisite in slaying victims not to batter them too much, as Rongo would thereby be insulted."

A third instance is as follows:—

"*Vaitamana's Speech.*—At one of our New Year gatherings a venerable man with silver locks named Vaitamana stood up and said, 'Young people, look at me. Do you know that I was one of those appointed for sacrifice to Rongo? These ears and this nose of mine were to have been cut off and divided out to each chief in token of office. This head was, in the phrase of those days, '*e kuto roroi*' ('a feast-provider'). It would not actually be eaten, but until I or some other suitable victim had been offered to the god of war no culture of the soil was lawful and no feasting permitted, blood-shedding alone being the order of the day. . . . Without a human sacrifice the drum of peace could not be beaten, nor a new paramount chief be appointed.'"

A remarkable saying, "Here are the pigs* we were in search of," was used by the delighted Apai to his followers when the young people cried out, "Alas, we too shall be slain." The cannibals surrounded them, &c. This and the accompanying note will compare with a like saying by a Maori when treacherously betraying the captain and crew of a European ship (see former paper, Transactions, vol. xxviii., p. 54).

An instance of human sacrifice in New Zealand will be given later on.

Mr. W. Wyatt Gill touches on the subject of *rahui* at page 205 of "Jottings from the Pacific," but gives the word as *raui*, omitting the letter *h*: "A green leaflet (of the cocoanut palm) tied round the upper part of the left arm was, and in some islands still is, a mark of idolatrous *tapu*. On Niutao (dried cocoanut) I watched the worshipper of a crooked post (the middle post of the three side posts supporting a roof) in which his god was supposed to be enshrined offering a sacred leaflet and three cocoanuts morning and evening. The extremity of a cocoanut-leaf consisting often of twelve leaflets, when cut off and bound with yellow sennit by the priest, constituted the fisherman's god on Mangaia. A similar device is used in a formal invitation of a chief to a feast, the sacred sennit being, of course, omitted. These leaflets are inserted in the thatch of the chief's house by the messenger, *but no word is uttered.* All *tapu* restrictions are still intimated by pinning to the soil

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* NOTE.—"A human being was never at Rarotonga called a 'pig' unless intended for eating. To this day the direst offence you can offer to another is to call him a 'pig.' This is the true Rarotongan curse."

or hanging on a tree an entire cocoanut-leaf plaited after a fashion supposed to represent the proprietor clutching the soil. All plants attached to that cocoanut-leaf become sacred. This is called a *rāui*."

In the "Journal of the Polynesian Society," vol. iii., p. 159, an account is given of the house of Keawe by Professor W. D. Alexander. This was a cenotaph or mausoleum for the deceased kings of Hawaii: "At the building of this *hale* (Maori, *whare*) Mr. Chamberlain writes, 'At the setting of every post, and the placing of every rafter, and at the thatching of every *wa* (or intervening space) a human sacrifice had been offered.' Human sacrifices had also been offered for each chief whose remains were deposited there—at each stage of the consecration—viz., at the removal of the flesh, at the putting-up of the bones, at the putting-on of the *tapa* (native cloth), at the winding-on of the sennit, &c. Mr. Chamberlain made a list of the names of twenty-three chiefs whose bones were removed in 1829 and deposited in a secret cave at Kaawa-loa, where they remained for nearly thirty years."

Here we have a small army of unfortunates who were killed—First, those whose deaths should insure the stability and *tapu* of posts and rafters, &c.; secondly, one to accompany each of the twenty-three chiefs or rulers; and a further multitude for each bone-scraping and other ceremonies enforced by this hideous custom as each of the twenty-three bodies were from time to time prepared for their long rest.

In vol. iv., p. 37, of the same journal Mr. Alexander Shand tells us that in the time of Rongo-papa, of the Chatham Islands, a *heke*, or migration, arrived there in the "Rangimata" canoe: "At Te Awapatiki the captain of "Rangimata," named Mihiti, and his people erected a post—first on *tahuna* (the sand-spit). This the *tangata whenua* (people of the country) took no notice of, but on seeing the *heke* put in another at Poretu (north side of the Awapatiki), and with it the image of their god Heuoro, they pulled them up." These posts were erected as indicating a taking-possession of the land—a *titiri*, or erecting the sacred mark of *rahui*.

To my thinking, it may be of interest if the two pedigrees of the Chatham Island natives (the Moriori) were studied by an expert in Polynesian languages, for I feel partly satisfied that some of the names given therein possibly relate to some deed or action; others to place-names touched at in migration; and later on to actual personal names.

At page 122 of the journal we read: "With Ro Tauira the children of heaven and earth separate to the world of existence; Te-ao-marama (World of Light) came forth, whose son was Rongo-mai-whenua (this was the ancestor who first

occupied the Chathams; this name in Moriori is figurative for land, as Rongo-mai-tere is for ocean). Then from this time the race of man grew until the time of Marupuku and Rongo-papa, the name of whose race was Te Hamata. This was the people who dwelt in the island before the arrival of the canoes "Rangi-mata" and others. These people were Hiti (= Whiti), or ancient ones and giants. Their bones lay at Te Awa-patiki, but were swept to sea by the breaking-out of the lagoon (*whanga*).

Now, suppose Rongo-mai-whenua to mean "report brought thither of the land" (Chathams); and Rongo-mai-tere, "report brought thither by swimming or floating"; then there arrived at Chathams Hiti, "the ancient people, the first known inhabitants." These people (Hiti) occupied the land for many generations, when came the celebrated voyager Kahu from Ao-tea (North Island of New Zealand) in the canoe (or by figurative expression) named Manu-kau-moana, "a bird swims the ocean." This bird may be either Kahu himself or refer to his canoe. He came, we are told by Mr. Shand, in the time of Kahu-tì, "garment of Ti."

Probably Kahu-tì = Kahu-tia, which may mean "Kahu comes"; or can it be the man known in Maori pedigree as Kahu-tia-te-rangi? Or might it be Paikea, said to have been shipwrecked at Mercury Island? The Chatham Island pedigree gives No. 83, Manu-kau-moana; No. 84, Kahu-tì; No. 85, Tatitiri; No. 86, Ko-rongo. We may read the two latter names thus: The newly arrived Kahu, in order to enforce his claim to certain lands, sets up a *rahui* (Ta-titi-ri). After various disputes, &c., with the original occupiers of the land (Ko-rongo) peace is made.

Kahu, the navigator, sails for Ao-tea (New Zealand) and Hawaiki, not being pleased with the climatic and other disabilities of the Chathams, a place where the *kumara* would not grow. We may ask, How did the Moriori know the ultimate result of Kahu's return, and was he Paikea who when shipwrecked was carried ashore at Ahuahu, Great Mercury Island, east coast of the North Island of New Zealand, on the back of a sea-monster? Mr. Shand also says, speaking of the first inhabitants of the Chathams, "the name of whose race was Te Hamata." This word might mean the people of the Flint age—those who had no worked stone implements, but used chips of obsidian as cutting implements.

The following communication has been kindly sent to me by Mr. Elsdon Best:—

DEAR SIR,— Te Whaiti, Tuhoe Land, 14th January, 1897.

Re *rahui*: The body of the man sacrificed for this would be buried at the base of the *pou rahui*, and would be termed a "*whatu*." In other

cases a *maro* would be used. This is a piece of *petako*, or some other sacred plant or shrub, which is suspended on *pou rahui* or buried at the base thereof. The *maro* of a *rahui* is termed "*kapu*." This *kapu* is subjected to powerful *karakia makutu*, strong enough to kill any one who interferes with what is rahui'd. It is generally concealed lest some person purloin it, in which case its virtue ceases, "*Mehemea ka kitea e te kai whanako, kua kore he niho o taua kapu.*" Allied to the above is the singular custom of placing the *iho* (severed umbilical cord) of children at certain spots to hold the *mana* of a *hapu* over their lands. A stone at Te Rahui, Waikaremoana, is a famous *takotoranga pito tamariki*. Many such strange customs obtained in the Urewera country, and information pertaining thereto should be collected without delay, ere it is too late.

Yours truly,

ELSDON BEST.

Note by T. White.—Pou, "a post"; *whatu*, chief meaning, "a stone"; *kowhatu-whaka-pakoko*, "stone images"; *maro* "a girdle for the loins"; *kapu*, "the hollow of the hand"; *makutu*, "witchcraft." A *kapu makutu* is when the *tohunga* (priest or wise man) is in such straits as to be unable to make a suitable *tuahu* or altar; he then may use the hollow of his hand as a substitute: this is called a "*kaupapa*." One meaning for *whata* is "an altar"; *mana*, "the strength or power of possession"; *hapu*, "the subdivision of a tribe residing apart"; *karakia*, "an incantation."

In a small but very interesting pamphlet, "Waikaremoana," page 16, Mr. Elsdon Best tells us further about Te Rahui:—

Travelling by Canoe on Lake Waikaremoana.—"We are now approaching the point known as Te Rahui, between which and Te Upoko-o-te-ao (the head of the world) is Otau-rito. Te Rahui is a kind of meeting-place of the winds, and is much dreaded by native canoe-men when the lake is rough. The saying at such a time is, '*Kia ata whakaputa i Te Rahui*'—that is, 'Be careful in passing Te Rahui.' If a canoe reaches Otau-rito safely when crossing in bad weather the paddlers thereof consider all danger is past. The *tohunga* (wise man) . . . now commences to initiate us into the ancient lore of Waikaremoana. Thus the *kaumatua* (old man): 'The large isolated rock you see at the point of Te Rahui is an ancient *whare pito tamariki*, or *takotoranga iho tamariki*, a spot where the *iho* (umbilical cord) of new-born children is placed as a *tohu whenua*. This custom, as it obtained in Tuhoe Land, was to place the *iho* of children of succeeding generations at certain spots, in order to preserve the tribal influence over the lands adjacent. The *iho* was secured to a stone, and after the former decayed the stone still maintained the name and power of the *iho*. This is an old custom, and I myself have seen it carried out. And across the lake, where you see the hill Ngaheni, at Opu-ruahine, there lies the *iho* of Hopa's brother, which preserves our *mana* over those lands. And it is from such dangerous places as Te Rahui that the lake derives its name of Waikare-whanunga-kore. *Ka puta i Te Rahui, a ko te ao marama* (If you pass Te Rahui you shall look upon the world of life).'"

I notice on the map of this district two other places named Te Rahui.

In this same pamphlet, at page 46, mention is made of the other word *rahui*, "a flock or herd" (in the fight at Pohatu-nui Pa). "Te Ariki escaped, but was captured after a long chase and slain. Tirawhi was enslaved." "*Te rahui kawau ki roto o Wairau*" is an expression applied to the refugees of Nga-whakarara by Tuhoe on account of the manner they flew from place to place—("The flock of shags (cormorants) within Wairau").

There seems reason to suppose that at the launching of some, or perhaps all, of the historical canoes leaving Hawaiki for New Zealand the success of the voyage was insured by the sacrifice of blood. This fact, becoming obscured by the lapse of time, has varied to the silly story of some of the would-be emigrants killing a boy, as, for example, "When the canoe was being finished a boy, seeing the dinner prepared for the workmen placed near by, came stealthily and ate the choice morsels. For this act Rata killed him at the launching of the canoe, and hid his body under the chips therefrom." Do not our own people act on the relique of a similar custom, but at the present time we make wine a substitute for blood. Man, from his inherent wickedness, will commit the same particular barbarity, and that without any knowledge of or communication with others of his kind, be they white, brown, yellow, or black in complexion, at long distances apart.

In *Nature* of the 22nd April, 1897, is this paragraph: "There is no reason to doubt that this custom (human sacrifice) prevailed among the early Aryans of India. The Trantras enjoin human sacrifice to Chandikâ. The folk-tales of India abound in tales of human sacrifice, and in the time of Sir John Malcolm there was a tribe of Brâhmans called Karhâda, which had a custom of annually sacrificing a young Brâhman to their deities. All over India there is a very strong tradition that new buildings, bridges, tanks, and wells should be secured against evil by the blood of some victim."

The Maoris have several different versions of the story of the bringing of the *kumara* (sweet potato) to New Zealand. In one Pani is the man or woman; another gives the credit to Kahu-kura (he of the beautiful raiment, or the rainbow.)

Judge Gudgeon, of the Native Land Court, tells us of another story in the "Journal of. the Polynesian Society" (vol. ii., p. 100): "Hoake and Taukata arrived in New Zealand by floating thither on blocks of pumice. They brought a supply of *kao* (dried *kumara*). When Toi, of New Zealand, tasted this new food he was delighted with the fragrance thereof. . . . Taukata explained where this

could be obtained, and he and Hoake set to work to make a canoe, which, when finished, was named "Te Aratawhao." The canoe started on the voyage under the command of Tama ki Hikurangi, and quickly arrived at the land of the *kumara*. Here they not only received a supply of *kumara*, but were also instructed as to the method of planting and storing the crops, and were, moreover, warned that if they wished to retain the *kumara* as a permanent article of food in New Zealand it would be necessary to appease the gods by the sacrifice of some human being, and suggested Taukata as the victim. This advice was carefully noted, and Tama ki Hikurangi returned with his valuable cargo. The seed obtained was planted in a *mara*, and when in due season the crop had been gathered and stored in the *ruas* provided for that purpose Taukata was slain as an offering to the gods.

In vol. iv. of the "Journal of the Polynesian Society" the Rev. Mr. Williams gives a *waiata*, or song, in which a Maori chief tells us that he buried his child at the foot of the main post when erecting his new house, according to the traditions of his people in such a serious undertaking.

Major Ellis, in "The Ewe-speaking People" of Africa, says that in times of danger, or when the people are especially excited, the priestesses of the temple protect themselves by laying in the paths leading to their quarters palm leaves, or is it branches? These have a sacred significance, and the riotous crowd are afraid to pass over even a single leaf. Thus man in all countries is greatly afraid of any "hocus-pocus" which he does not rightly understand.

The French navigator Crozet, after the death of his superior, Marion, who was killed and eaten by the Maoris, made use of an expedient when taking from the shore some of his people who had been collecting wood. The natives, seeing those whom they regarded as a prey about to escape, began to close in on them, but Crozet, with great coolness, drew a line around on the sand of the beach with the butt of his musket, and commanded them on peril not to pass over the mark. This had the desired effect, and the party were safely embarked. Captain Cook, in a like difficulty, made use of the same expedient, with equal success. This custom of the *tapu*-mark must have been in use among the Polynesians, but this fact would not be known to the two commanders.

The Rev. W. Wyatt Gill tells us that at the island of Nanomanga, when his party landed there, "a charmed circle was drawn round the beach, beyond which none of our party was permitted to wander. We were the first visitors fortunate enough to escape being 'devilled'—*i.e.*, detention for hours in a broiling sun, whilst the heathen performed incantations to prevent the introduction of disease."

Supplementary Notes.

Titi (the setting-up) *o* (of) *kura* (the *tiaha*, or ornamental staff painted with red-ochre as a sign of *tapu;* or the *tiaha*, coloured red by feathers of that sacred colour). *Tiaha*, from *tia*, "to stick in," "to drive in a peg or stake," also "feathers stuck in for ornament," "to place feathers in the hair"; and the suffix *ha*, "the agent, or one who has or does a thing": giving, in full, *tia-ha*, "one having ornament of feathers." These red feathers may have been the sacred emblem of the staff. (See Tregear's "Maori-Polynesian Comparative Dictionary" for "painted staff": Kura, No. 4.)

Rahui, either two distinct words or a word having widely differing meanings: *Rahui*, "a flock or herd of birds or other living objects," and *rahui*, "a ceremony of *tapu*." I take the aforesaid message to translate, "Here are a herd of pigs for you," thereby leading to the inference that the ship's stores and crew should be used as food by the receiver of the message. This tragedy was so carried out. The other translation, "Here are sacred pigs for you," is hardly probable. In any case, "herd" and "sacred" could not appear in this sentence in conjunction.

Shortland writes, I believe, "Wakatane," not "Whakatane"; and I notice both he and Dieffenbach omit the "h" in many words purposely, leading to the inference that this was a customary habit with certain Maori tribes. Shortland gives the traditional origin of the place-name Whaka-tane. The crew of "Tainui" having arrived at New Zealand, landed at this place, and climbed inland, leaving the canoe on the beach. A girl, seeing the incoming tide and raging waves endangering the canoe, exclaimed "*Whaka-tane*," "Let me play the man"—*i.e.*, go to the rescue of the canoe (presumably assisted by the other women). *Whaka*, the causative prefix; *tane*, "a man."

Mr. Alexander Shand, of the Chatham Islands, publishes a Moriori pedigree in the "Journal of the Polynesian Society," vol. iv., page 43. In the personal names there given are: No. 83, Manu-kau-moana, "a bird swims the sea"; No. 84, Kahu-ti, "at the time of this ancestor Kahu arrived" from New Zealand; No. 85, Ta-titi-ri, "the knocking-down of the *rahui*"; No. 86, Ko-rongo, "peace is made." Have we not here the following information: *Kahu-tia*, "Kahu sticks in a peg or post"; *ta-titi-ri*, "it is knocked down by the inhabitants of Chathams"; *ko-rongo*, "after which peace is ratified or entered into with the new arrivals."

At a later date, in the time of No. 157, Rongopapa, a *heke*, or migration, of "Rangimata" (canoe) came to the Chathams, when Marupuku, who lived at Auapatiki, con-

tended with Mīhīti, the captain of "Rangimata," and his people on their landing there, pulling out a post erected by them to indicate taking possession of the land. "It is said the *heke* put in one post, first on the sand-spit (*tahuna*) : this the *tangata whenua* took no notice of; but on seeing the *heke* put in another at Poretu (north side of the Awapatiki), and with it the image of their god Heuoro, they pulled them up."

In the "Journal of the Polynesian Society," vol. v., page 153, under article "The Maori Whare," by the Rev. H. W. Williams, a note is appended by the editors (Messrs. Percy Smith and Edward Tregear), which I have referred to in the body of this paper. This I am now enabled to bring to your notice :—

"In the building of all large houses intended for meeting-places of the tribe or for the entertainment of visitors, on the erection of the main pillar, or *pou-toko-manawa*, a slave, or in some instances a member of the tribe, was sacrificed, and, after the abstraction of the heart, the body was buried at the foot of the *pou-toko-manawa*. The heart of the victim (*whatu*) was cooked and eaten by the priest, or *tohunga*, presiding over the work, accompanied by *karakias* (incantations). This was the practice in some districts, as, for instance, among the Arawa tribe; but the Rev. Mr. Williams tells us that the victim (*whatu*) was buried at the left-hand back corner of the house, at the base of the *poupou* in that corner. Amongst the Urewera tribes the *whatu* was called '*ika purapura*,' and it was buried at the foot of the *pou-toko-manawa*. After some time the bones may be exhumed and taken to the *tuāhu* (altar), and there used as a *manea*, or means of beneficial influence for the owner of the house. *Manea* means the *hau* or spirit, essence of man, and also of the earth. The following lines from an old song are the only references (in song) we recollect alluding to this custom; it is part of an *oriori*, composed by some member of the Ngati-kahu-ngunu Tribe of the East Coast :—

Ka whaihanga Turaia i tona whare,
Ka makaia tana potiki
Hei whatu mo te pou-tua-rongo,
O tona whare, o Te Raro-akiaki.

Then Taraia built his house,
Placing his youngest child
As a *whatu* for rearmost pillar
Of his house, of Te Raro-akiaki.

Taraia was a very noted ancestor of the Ngati-kahu-ngunu Tribe, and the house whose name is given above was erected at Herepu, near Karamu, Hawke's Bay."

ART. XLIII.—*The fleeing Maru-iwi walk over Glenshea Cliff at Night.*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute.*]

WE of the present time should endeavour to the utmost of our ability to collect and place on record such fragments of the ancient history of New Zealand as may come within our reach, more especially those portions which relate to the life-history of those people who inhabited this land before the arrival of the Maori in the "Arawa" and "Tainui" canoes, and others of that date. In this paper I propose to add a supplement or small addition to a well-written article by Mr. Elsdon Best, of Rotorua, which is here copied from the pamphlet entitled "In Ancient Maori Land," page 37.

"MARU-IWI: Te Heke a Maru-iwi ki te Po" ("The Descent of Maru-iwi to the Shades"), by Elsdon Best.

"The Maru-iwi were one of the aboriginal tribes of New Zealand, and originally occupied the valley of the Wai-mana River, where they had many a fortified pa, the principal one being Ma-pou-riki. The whole land was occupied by the tribes of the *tangata whenua* [men of the country—T.W.], whose ancestors held these lands long before the historical vessels came from the Hawaikian Fatherland, which lies far away, across the great Ocean of Kiwa. When the ancestors of the present Maori people became numerous in Ao-tea-roa [New Zealand], then wars arose between the two races, and many battles took place, and the long peace of the Great White World was broken at last. Then was known the evil which comes with war and strife. The clash of arms was heard in the old-time homes of Te-tini-o-toi [the descendants of Toi—T.W.], the sound of the war-trumpets [*pio-tara*—T.W.] echoed far and wide, the rivers and lands of the descendants of Maui were stained with the blood of Maru-iwi and Te Maranga-ranga, of Te Po-kiki and Te Po-kaka.

"Maru-ka was a chief of Te Maru-iwi [*iwi* = tribe—T.W.]. He and Koira, of Ngati-awa [*ngati* = descendants of: these were a Maori people—T.W.], had a long argument concerning the *kumara* [sweet potato—T.W.] of Rehua and of Wha-nui. They came to high words, and Maru-ka struck Koira on the face. Then was Koira dark in his heart, and he went forth and sought his *tupuna* [ancestor—T.W.] Rakei-ao. A man of great knowledge was Rakei-ao, versed in the sacred lore of his race, and a *tohunga* [priest or learned man—T.W.] of

great fame. And Koira said to this *tohunga*, 'I have been insulted by Maru-ka, of Te Maru-iwi; yea! even struck by that man, sir! It is not well that this tribe should remain here. Rather let them be driven from these lands, driven away towards the setting sun.' Rakei-ao, the man of knowledge, agreed to this; he said, 'Let this place be swept and made quite clean.' This was done, and then the priest said, 'Now you must dig a hole, even a deep hole, that I may perform therein the necessary ceremonies and incantations [*karakia*—T.W.] to enable me to drive away the Maru-iwi to other lands. But you must be careful and not laugh at anything I do, or my work and prayers will be in vain.' So ended the words of Rakei-ao, the *tohunga*. Then this priest, with his sacred girdle around him, descended into the hole which had been prepared. He did not descend in the ordinary manner, as other men do, but went down head first, and performed the necessary ceremonies in that position. The meaning of this was, 'a driving-away or expelling of Maru-iwi' (*hei whakatere-tere i a Maru-iwi*). Even so were Koira and his people enabled to expel the Maru-iwi from Wai-mana, their ancient home. And they fled—fled with a great fear upon them—far away from their well-loved homes of many generations, away to the region where the sun goes down.

"So went forth the Maru-iwi, pressing onwards through the ancient lands of Te Rarauhe-maemae and Te Ma-rangaranga, of Te Po-kiki and Te Po-kaka. They left their tribal lands, they left the hills and valleys, they left the rivers and forests. As they looked back at the well-known mountains which encircled their former home they paused and greeted each known peak and deserted valley, the forests wherein so many generations of their tribe had hunted and fought, the sacred places wherein lay the bones of their dead. Far away across the White World was borne the wailing of Maru-iwi as they chanted a song of farewell to the Land of the Ancient People, for the Maori had come, the Maori of Hawaiki, of the Dark Ocean, trained to war and slaughter in the crowded isles of Polynesia.

"So fled the Maru-iwi with the battle-cry of the Coming Race ringing in their ears, with the fear of death upon them. By rugged mountains and lonely valleys, across swift rivers and pathless jungles, over wide plains and amidst the murmuring 'children of Tane' [forest-trees—T.W.] the Maru-iwi fled. They saw in each moving shrub an armed enemy; they heard the relentless foe in the sighing winds, in the mysterious voices of the night. Strong men hurried forward to an unknown haven; women carrying little children pressed wearily onward; the old and the weak died by the way; still the Maru-iwi fled. They reached Titi-o-kura, and the black

fear was on them, for the savage foe may be hard upon their trail. Who might know? The dreadful foe, who killed for killing's sake; who slew old and young of both sexes; who roasted and ate the bodies of the dead—a truly terrible foe. Thus the Maru-iwi hurried on. In the darkness of night they clambered up the rugged mountains, they traversed the darkling woods of the unknown land. The foremost reached a deep chasm in the range — a cañon with perpendicular walls. Unknowingly they stepped into the abyss and met a fearful death; unknowingly the others pressed on, and were in turn forced into the gulch by the pressure of those behind them. And there in that dark and fearsome chasm lay strong men and feeble women, warriors and little children, crushed and lifeless. For the death they dreaded from the rear had met them face to face in the mountains of the Ririo.* Hence came the expressions:—

Te Heke a Maru-iwi ki te Po.
Te Heke a Maru-iwi ki te Waro.

These have come to be used as synonyms for death. And the few survivors of Maru-iwi fled onwards to Wai-rarapa and to the Land of the Pounamu [the South Island—T.W.], and their name is lost to the World of Life, and no man may know their descendants. Only this remains: 'Te Heke a Maru-iwi ki te Po!'

"And Maru-a-hangaroa, of Kahu-huna, married Rakei-ao [the *tohunga* of this story—T.W.], and had Puhi-awe, who married Awa-tope, and had Ira-wharo and Koira; and Koira had Koko-wai, who had Tua-hina-rau, who had Hika-pua-pua, who married Te Uru-hina, and had Te Rangi-patai and Hine-oho; and Hine-oho had Tua-hiwi, who had Te Mokena, who had Hamiora,† who had Te Mate-kuare, who had Whare."

This ends Mr. Elsdon Best's graphic description of this terrible incident of the olden time.

Excluding Koira, from Koko-wai to Hamiora gives seven generations, which, taken at twenty-five years for each generation, gives one hundred and seventy-five years, and add to this the two persons named after Hamiora and we have two hundred and twenty-five years as having lapsed since the flight of Maru-iwi.

The Maru-iwi lived contiguous to the east coast, in a district till lately known as "the King-country." The pakeha

* "The Ure-wera inform me that the Ririo is the leading *atua* (god, spirit) of the Taupo tribes, as Te Rehu-o-tai-nui is of Tuhoe, and Makawe that of the Arawa tribes.

† "Old Hamiora, of Ngati-whare, who gave the above information [concerning the flight of Maru-iwi.—T.W.]."

was forbidden to enter this part of the North Island up to within the last few years, but the Maori has now allowed a road to be surveyed therein. Hence the allusion to driving the Maru-iwi towards the setting sun.

For nearly ten years I resided on a property known as "Glengarrie," situated northward of Napier, and it may be about half-way between the latter place and Titi-o-kura, the place mentioned by Mr. Elsdon Best as passed by the Maru-iwi in their flight from the Maori of the north. Attached to the Glengarrie land was, in my time, a part named "Glenshea," which the Maoris have told me they called "*Kuri-paka*" (the brown dog). (A chestnut horse was once pointed out to me as of the colour *paka*.) At this place there are what I may term perpendicular walls of highly water-worn and polished boulders about the size of a man's fist, intermixed with others slightly smaller. These boulders are themselves of a blackish colour, but, being cemented about by ferruginous particles, the *tout ensemble* is as of a red conglomerate rock, very hard and solid in texture. I have since wondered if there was some mistake in interpreting the Maori saying, and that possibly *kiri paka* (the reddish-brown or burnt-looking shingle) might be the name of this place. This wall of conglomerate runs along the northerly face of the ridge, and is mostly covered by the surface-soil on the flat top of the ridge, showing out below after the manner of a ha-ha or sunken fence in England, giving some 8 ft. to 15 ft. of a perpendicular exposure, when it is again hidden by the soil of the sloping land below. This wall is here sufficiently formidable to any person travelling on a dark night; and the more so in the condition in which I first saw it, when the land was hidden under fern and tutu, breast high, and often over a man's head—but this is merely a preliminary sketch, and to record the Maori name of the place.

Along the westward boundary of this land flows the Manga-one River, a tributary of the Tutae-kuri. This divides it from land then called "Pa-toka" (the *pa*, or fort, of the rock). The Manga-one is on both sides mostly hidden away under gigantic precipices. At some few places (mostly where the side streams flow in) the descent is more gradual, but many of these side streams are confined between even worse cliffs than those of the main stream. Many of these cliffs are formed by the before-mentioned conglomerate rock, nearly as hard as iron, standing on a great depth of papa rock. The lower, being the softer rock and more easily weathered, is mostly overhung by the upper strata. Now, hide away these truly awesome depths by an upper coating of the tall fern and tutu (which held sway until the improving hand of the

pakeha caused their disappearance), and you can see the dread place which engulfed the fleeing Maru-iwi.

For some eight or nine years certain Maori people came from about Tara-wera and shore my sheep. They were under the leadership of a young *rangatira* named Petera, whose father, a chief of considerable influence, was also named Petera, which I suppose to be the Maori of Peter. (The father was probably Petera te Puku Atua, of Rotorua, Arawa Tribe—see pedigree, March number, 1894, vol. iii., of the "Journal of the Polynesian Society," by Major Gudgeon. Henare te Puku Atua, a chief of Ngatiwhakane, brother of the latter, formerly Assessor, Native Lands Court, died in August, 1897. His ancestor Taunga came in the "Arawa" canoe twenty-three generations ago.) These Maoris did their work well, and were less trouble than the average pakeha shearer. They brought their own cook, fleece-pickers, and rollers-up, and also their children and dogs. One season they told us about a whole tribe (or most of them) who, when fleeing from their pursuers, walked straight on over the terrible cliff at Glenshea. These people were fleeing from the north by way of Titi-o-kura, and coming to that branch of the Manga-one bounding Glenshea from Rauka-moana (now held by Mr. John More), and it being night-time, they walked straight onward into the empty space, and fell headlong into the depths below.

Possibly these people, even at that time, had used a well-beaten but very narrow track which led through the tall fern and tutu in a southerly direction along the ridges from the narrow dividing-ridge between the aforesaid creek falling into the Manga-one and the stream which here takes its rise and is a tributary of the Esk or Petane River, the one flowing west and the other to the east. This old Maori track followed on from Titi-o-kura to Puke-tapu and Moteo, and was in use when I lived near by. (Now the pakeha roads have altered all this, and the old track has many fences built across it, and is obliterated from all but the memories of the elderly people of both races.) We might assume that the Maru-iwi, when struggling along through the tall fern in the dark, lost the track when nearly arrived at the head-waters of the two streams, and so went to their death over the precipice on the left-hand stream.

Art. XLIV.—*Browning's Vision of Life.*

By E. A. Mackechnie.

[*Read before the Auckland Institute.*]

Those who are accustomed to the sentimental sweetness of Moore's melodies, or the exquisite smoothness of Tennyson's verse, will turn, I fear, with more than impatience from the poetry of Robert Browning. And yet writers well qualified to judge unhesitatingly declare that his poems disclose the highest poetic insight that has been known since Shakespeare. Why this distaste to such high excellence? He is charged in the first place with being obscure; but much of his obscurity is due to his efforts to express his thoughts with conciseness. Readers of the present day desire to grasp the meaning of an author with as little trouble to themselves as possible, and when obstacles to their doing so occur which the writer, they think, could easily have avoided the volume is thrown aside and seldom resumed.

Browning, it is generally admitted, possessed a large command of language and great facility of rhythm. It was not, therefore, want of words or rhyme that induced him to place his thoughts before the public in the manner he did. Most of his poetry is easily mastered, particularly his ballads, the lyrics and songs scattered through his longer poems, the Cavalier Tunes, and others. The language he employed was, in his opinion, always the best and most appropriate to the subject. Why, then, is he so often obscure, abrupt, and non-poetical? Every original thinker, be it remembered, expresses his thoughts in the way he considers best adapted to exhibit their force and beauty, to convince the intellect, warm the imagination, and rouse the emotions. And this is borne out by Browning's own testimony. "I can," he says, "have little doubt that my writing has been in the main too hard for many I should have been pleased to communicate with, but I never designedly tried to puzzle people, as some of my critics have supposed." As a worker is endowed by nature so he works. This is his method, his style, his mode of treatment, his individuality, in fact.

It should be borne, too, in mind that the higher men's gifts are the less are they understood by their fellow-men. Shakespeare is known to the general public by the interpretation of a few of his plays by actors of ability and genius; but the greater portion of his dramas and all his poems remain a sealed book to most persons, or nearly so. Milton, whose

name is frequently on men's lips as a great poet, is even more generally neglected; and the "Divine Comedy" of Dante, though presented by Carey and other translators in an attractive English garb, is only read by a few lovers of Italian literature. That great and original powers are not readily appreciated is clear from the admission of Sir Joshua Reynolds, who acknowledges in his "Discourses" that he was greatly disappointed on first viewing the masterpieces of Italian art; and that he devoted six months to their study before he discovered their superlative excellencies. This admission by no mean master of his art proves, if proof were required, that we cannot reasonably expect to appreciate excellencies of the higher order of minds without some little study on our own part. And in reference to this difficulty we may recall with advantage what Ruskin considers due from readers to great writers. In "Sesame and Lilies" he says, "The metal you are in search of being the author's mind or meaning, his words are as the rock which you have to crush and smelt in order to get at it. And your pickaxes are your own care, wit, and learning; your smelting-furnace is your own thoughtful soul. Do not hope to get at any good author's meaning without these tools and that fire." The question, then, is: Is it worth while, for the sake of Browning's thoughts, to devote some degree of study to the language in which he has clothed them? Men of taste and judgment say distinctly that it is. The greatness of his thought and his wondrous insight into the workings of man's spirit are acknowledged by the learned few, and these undoubtedly fix the true position in literature of great writers. The masses simply echo the opinion formed by the superior intelligence of highly educated minds, without comprehending the worth or feeling the beauties they praise. Browning lived to see a first edition of some early poems, unsaleable at the time they issued from the press, realise at auction no less a sum than £25. From this we may fairly conclude that the popularity of his writings will surely though slowly extend, and receive a more general recognition than has yet been accorded to them.

But there is another objection which to my mind fully accounts for his unpopularity, and which cannot be removed or overcome. I refer to the subject-matter of his poems. He depicts the inward workings of man's spirit, and his power to do so was great and varied. From his earliest literary production to the last he ever dwells upon that one subject. The soul, he declared, is the only thing worth study, and to that study he devoted his life. To the few who take a deep and absorbing interest in psychological studies these elaborate poems on the subject dearest to their hearts are held in the highest estimation—beyond all praise. But

such studies are entirely unsuited to the habits of the every-day man, whose whole thoughts are engrossed by business or pleasure, and who can discern no attractiveness in an analysis of the secret motives which prompt to action, and shape and guide men's lives.

This want of interest in the subject of the poems themselves, and not the obscure phraseology in which the thought is expressed, appears to me the true cause of Browning's writings not being more generally read. The subjects chosen are, possibly—as some contend—not suited to poetry, which is to work upon the feelings of men. Be this as it may, Browning is not popular in the general acceptation of the term. "I should have been gratified," he says, "with moderate success, but I am not discouraged at the want of it." And this from a reason of his own. The value of all life-work, he held, was not the estimate put on it by others, but by its power to influence and mould for higher purposes the character and disposition of the worker. And so he was content to work on, trusting to time to do him justice.

If we glance over the leading events in the world's history we note, with singular interest, the advent of a certain order or class of minds which comes to the front at special periods, and makes the deepest impression on its own age, and not unfrequently many after ages. These periods are generally periods of unrest, when the human mind, either from gross ignorance or over-refinement and pride of intellect, is full of doubt and unbelief as to the existence after death of man's spirit. Browning was endowed with a mind of that order, with its noble aspirations, and its power of viewing, not through a glass darkly, but as a reality constantly and clearly seen as in broad daylight—the spiritual nature of man, the true import of his life and its manifold duties. Such minds are moved also by an irresistible impulse to impress their belief upon mankind. The earnestness and singular freedom and fearlessness with which this is done evidences the sincerity of their convictions. These distinguishing qualities have frequently been portrayed, and would appear to have been fully developed, in Browning.

In the present highly sceptical age we might expect to find, as in reality we do find, some of our poets speaking on the momentous questions of life and death, and the meaning of life, with great force and eloquence. Conspicuous amongst these are Tennyson and Browning. The one charming the ear of the masses by the music of his verse, the other claiming the serious attention of a select few by his deep original thought and keen spiritual insight.

The poetical faculty, allied as it was of old with the prophetic, is perhaps the grandest conferred upon man. It

is truly divine. As we gaze upon the wondrous beauty of the world, with all its fair and glorious forms, and realise the marvellous simplicity of the laws which sustain and govern the universe, we can understand in part the pride and joy of Aprile, the poet, in "Paracelsus," when he exultantly exclaims—

> God is the perfect poet,
> Who in creation acts His own conceptions.

I am tempted to place before you to-night Browning's vision or view of life by two considerations—first, because I believe his writings are but little known here; and, secondly, because it is alleged they have proved a source of comfort and consolation to many persons depressed by the trials of this life and the uncertainty attending the life to come. The few minutes at my disposal will enable me only to give a bare and, I fear, most imperfect outline of those views; but I shall endeavour to emphasize the salient points presented by the leading ideas by a line or two from his own poems, assuming always that they are personal as well as poetical utterances.

"Man," says Browning, "is a being created for two lives—a finite life and an infinite life; and to live wisely we must take due account of both, neglecting neither the one nor the other." The concerns of this life, "since flesh must live," necessarily claim a portion of our time and attention, but to occupy our entire earthly life in accumulating material wealth, and to be content with the pleasures and enjoyments of a mere animal existence, is, in his estimation and from his point of view, strange and unaccountable. A man by the development of the brute instinct of cunning within him may succeed in some ignoble pursuit, for every energy of his being is enlisted in gaining what he desires.

> The low man seeks a little thing to do,
> Sees it and does it.

He is capable of better things, but he does not desire them. He dwells on no elevating thought, makes no effort to rise in the scale of being, and has his reward. In the utmost contentment of heart he lives on in spiritual sloth and indolence

> —— left in
> God's contempt apart, with ghastly smooth life.

On the other hand, the man who seeks life plainly in its twofold capacity, who, moved by a spiritual ambition, strives to elevate himself to a higher level in the scale of being and prepare his soul for the approaching change, frequently fails.

> This high man, with a great thing to pursue,
> Dies ere he knows it.

This is not failure, Browning contends, but only apparent

failure. In the spirit world it is success, for the true wisdom of life is to bear and overcome trials and temptations, to prove and strengthen the soul for its independent existence.

Browning was an optimist of the most pronounced type, declaring his belief that all things in this world were ordered for the best and in the true interests of man. If there is pain in the world, and who can deny it? then, he asks,—

> Put pain from out the world, what room were left
> For thanks to God, for love to man?

If there is evil overpowering the good in many instances so far as we can discern, he urges,—

> Shall we receive good at the hand of God,
> And evil not receive.

And even when he views the close by suicide of an unhappy life his large charity and great human sympathy enable him to say hopefully—

> That what began best can't end worst,
> Nor what God blessed once prove accurst.

His religion has been designated the religion of love. Heaven, he says, is love. Love is the source of and permeates all creation. Power and love he holds to be one and the same. Power existed, he knows, from the first; and he declares that—

> Life has made clear to me
> That, strive but for closer view,
> Love were as plain to see.

Paracelsus, in the poem under that name, strives to attain knowledge, the power of doing good to his race; the poet Aprile seeks love from and to all animate and inanimate things; and at the end of life they discern clearly that they have failed, for power in the one case has not been strengthened by love; in the other love exists without the power of doing good. The two combined is the spirit of the universe.

We often hear regret expressed that no certain knowledge of man's destiny after the close of this life has been vouchsafed to us, but Browning holds there would be no gain to the individual by such knowledge. The certainty of a future state would destroy the very purpose of our existence here. Many of his poems are illustrative of this view, the most elaborate study in this direction being the epistle containing the strange medical experience of Karshesh, the Arab physician. The New Testament story of the raising of Lazarus had for Browning an intense interest, not so much from the facts or narrative of the event as from the effect it would have upon the after-life of Lazarus. He was concerned to know what would be the feelings, thoughts, and actions of a man under such circumstances. This novel view of the case proved very attractive to him, and occupied his thoughts

frequently, the question ever returning to his mind for consideration. What would be the effect upon a man if he were to die, rise again, and return to ordinary duties of every-day life? How would it be if—

> Heaven open'd to a soul while yet on earth,
> Earth forced on a soul's use while seeing heaven?

That was the question he pondered over and endeavoured to realise. He thereupon, pursuing his usual dramatic method, as in "Cleon" and other poems, imagines an Arab physician on his travels to have met Lazarus at Bethany some years after his resurrection, to have held converse with him, and to have marked with the greatest interest his bearing and conduct as he takes up his after-life. In writing to his former master in the profession the physician gives an account, among other professional matters, of this singular case, remarking—

> 'Tis but a case of mania—subinduced
> By epilepsy, at the turning-point
> Of trance prolonged unduly some three days;

and holds that by some drug, spell, stroke of art (unknown to him, and which were well to know) the evil was subdued, and the man restored once more to health. Continuing his narrative of the occurrence, he gives the information obtained from Lazarus direct: "And first the man's own firm conviction rests that he was dead (in fact, they buried him)—that he was dead and then restored to life by a Nazarene physician of his tribe. Sayeth, the same bade 'Rise,' and he did rise." And in describing Lazarus's bearing and conduct he writes, "He looks like one who had seen life beyond the grave and had returned with its impression constantly before him—'the spiritual life around the earthly life.'" The grown man eyes the world like a child; meditates with folded hands; seldom speaks except when spoken to; cares gently even for the birds and the flowers; submits himself to the heavenly will; is moved to indignation by the folly and sin of men; he acts not in accordance with his earthly surroundings, but in reference to his future state—

> His heart and brain move there, his feet stay here.

Hence Browning concludes that certainty about the life to come would render duty impossible, and that such knowledge has been wisely withheld from us for man's good simply.

Every great teacher has placed before the world very high ideals for imitation. The perfection specified and to be striven for is not always attainable by human nature even at its best, but it enables us to aim high, though we may fall far short of what we strive to accomplish. Browning teaches no less,—

> A man's reach should exceed his grasp
> Or what is heaven for?

He was convinced that these strivings for better things were the much-needed discipline of the soul. His poems illustrative of this view are very suggestive of the higher aims of life, and the necessity for them.

Browning's idea of death is very characteristic, clear, and pronounced. To him death was not extinction, but simply a change from one form of life to another—progress being essential to life,—

> Never dream
> That what once lived shall ever die.

To him it was growth or expansion of the spiritual portion of our nature freed from the material elements of the body. "There is no such thing as death," he exclaims. "Never say of me that I am dead"; and this he repeats in ever-varying measures. To all those who have derived spiritual benefit and comfort from his poems, and all in whom they raise pleasant thoughts of him, he adds,—

> Know my last state is happy, free from doubt
> Or touch of fear.

During the Victorian age science has made, beyond doubt, great strides along many lines of research and inquiry; the human mind has expanded under the stimulus, and new thoughts and views are opened up in every direction. The world is under the greatest obligations to such men as Darwin and Huxley, Spencer and Tyndall, Wallace, and others prominent in the science roll, for their life-labours have conferred manifold benefits on the human race. But the crowning service rendered to the world by science is, so it seems to me, the enlargement of our conception of the universe. From the days when men thought the earth an immense plain and the stars points of light shining through holes in the sky to our present-day enlarged conception of the universe, with its myriads of worlds around us, how vast, how marvellous the change. The discoveries of science are frequently in advance and in apparent contradiction of the religious faith of the day; but time rectifies that, enlightens the mind, disperses the mists of superstition, purges away the idolatries of the world, and leaves us with a greater and juster idea of the Supreme Mind. But these benefactors of their race represent only one-half of human nature and its order, the physical. The dual nature of man is taken little notice of; the mind, the conscience, the spiritual portion are left without an effort being made to interpret them. It is necessary, however, to consider the other half, if we desire to obtain a just appreciation of the whole. It is along this frequently neglected line of inquiry that Browning's thoughts incessantly travelled. We cannot, of course, form any conception of a soul—what it is like—for no living mortal has seen one. It is only when it becomes

disentangled from the mechanism of the body that we may expect to see it in completeness, with the impress upon it of its earthly experience. But as the bodily eye is not constructed to discern a spirit (so I deem), to obtain cognisance of it we must be in the spirit world ourselves, and discern it by a spirit sense. But the soul makes its presence in the body known and felt by its workings. So certain was Browning of its existence that his biographer suggests this line from one of his poems as his most appropriate epitaph:—

> He at least believed in soul, was very sure of God.

Browning possessed in no ordinary degree the scientific spirit of patient research and minute analysis. He threw himself, as it were, into the very mind he represents, showing it from within, laying bare the thoughts, passions, and secrets of that mental life, the very soul he depicts. This is the study which lent interest to his life, and to which we are indebted for those profoundly interesting psychological pictures which give in a marvellous manner the workings of man's soul. He did not consider the mysteries of the human mind and human thought impenetrable, but to be reached by men of science, and in accordance with scientific methods. Nor need we despair of something in this direction being eventually done, when such works as Kidd's "Social Evolution," Drummond's "Ascent of Man," Professor Romanes's "Thoughts on Religion," and the like, are given to the world. The analysis of the mind or its movements, imperfectly known at present, will approach nearer and nearer to exactness. The principles that should guide us in the inquiry will become better known, and lead to important discoveries. Such inquiries will be taken up by men of skill and proper training, till possibly we may—

> ——have this plain result to show
> How we feel, hard-and-fast as what we know.

Tennyson has frequently been called "the poet of the age," and from the large circle of his readers and admirers he may perhaps be justly considered so. But the music of his verse, like other bygone music, having supplied the requirements of the age, will probably cease to command attention for any lengthened period. But the admirers of Browning claim for him a more enduring fame. He depicts man's thoughts, and loves, and hates, the aspirations of our spiritual nature, the trials and disappointments of this life—all, in fact, that makes humanity. He has not inaptly been styled "the dramatist of the soul," and as such they anticipate he will take a position in the world's estimation second only to Shakespeare.

Nothing can show more clearly the characteristics and

disposition of the two poets than their final strains, or what may be considered such. A solemn calm broods over the whole of that most perfect lyric, "Crossing the Bar." The tranquil close of the day, the evening bell, the soft twilight slowly deepening into night, then the dark. As the spirit draws near the great ocean of eternity the failing voice breathes hope and seeks guidance—

> I hope to see my Pilot face to face
> When I have crossed the bar.

Amid the soft melody of the lines we detect the prevailing impression on the poet's mind—darkness and uncertainty. Browning, equally characteristic, selects as his final strain a kindred theme. But how different the treatment of the subject. Tennyson heralds the dark, Browning the dawn. Darkness had fallen upon him; "it was in the silence of the sleep-time"—the sleep of death; and he imagines some one, looking upon the grave in which he lies imprisoned by death ("as fools think," he says), to have asked, "Who?" He glances back, as it were, upon the work of a long life, which sets forth the principles he held firmly from early manhood to the last, and in the strongest and tersest language at his command re-echoes the lessons he taught. From the grave he would evidence himself and his convictions with the same boldness and earnestness that influenced him through life, and so to the question "Who?" he makes reply:—

> One who never turned his back, but marched breast forward;
> Never doubted clouds would break;
> Never dreamed, though right were worsted, wrong would triumph;
> Held we fall to rise, are baffled to fight better,
> Sleep to wake.

The characters of these two poets, sincere and true men in all respects, are distinct but equally noble. Each has in his own way devoted his life to establish high ideals for the guidance of men, and to make clear "the substance of things hoped for." They were not prophets in the ordinary sense of the word, but visions were vouchsafed to them of incomparable beauty, and though it may be said—

> That after prophecy the rhyming trick
> Is poor employment,

these poets, like the poets of old, appealed to the intellectual, the moral, and emotional side of human nature, and otherwise followed closely in their footsteps, teaching with equal poetic power the same grand belief. Surely it would be well if the inquiring spirit of this age were to ponder more deeply that truth which appeared so clear to the strong mind of Browning—

> We sleep to wake.

Art. XLV.—*A Poet's Socialism.*

By E. A. Mackechnie.

[*Read before the Auckland Institute.*]

Men with active imaginations have, in all ages of the world's progress, derived pleasure from creating an ideal community, dwelling in "a land where all things always seem'd the same." The locality selected is frequently an "isle of bliss," whose latitude and longitude are unknown; and the imagined inhabitants, and their modes of life, are shadowed forth, with more or less clearness of outline, in either prose or verse. If feelings of compassion are easily aroused in the mind of the creator of such an ideal, his thoughts take the form of a scheme for reorganizing society, coloured invariably (as we might expect) in striking contrast with the evils produced by our present social order.

At the present day the laws and regulations relating—one would have thought exclusively—to these ideal states seem to claim the serious attention of statesmen as practical measures likely to advance the good order, prosperity, and happiness of mankind. The subject is a highly suggestive one, and I have thought it might prove sufficiently attractive to claim your attention for a few minutes this evening.

That there is a vast change impending over society, for good or evil, no observant person can fail to note. The rapidity with which that change is approaching can well be gauged by examining the socialistic doctrines put forth a few years ago, and noting the way in which they were received then and now. The "Political Justice" of William Godwin, published in 1793, was declared to be an epoch-making book, and to have changed the thoughts of the world; but this could hardly be unless previous literature on this subject had been entirely forgotten, which was not the case. Plato, in his "Republic," expressed much the same views some four hundred years before the Christian era. Both these writers required equal justice and equal rights for all men; and their proposals in regard to women would, if carried out, have led to their extreme degradation.

In referring to these early social schemes I have no desire to detract from the force or originality of Godwin's writings. My object is to draw attention to the existence of similar ideas from remote periods, to the persistence with which they haunt the human mind, and to the remarkable progress they have made of late years towards fulfilment. Godwin's

writings were regarded in his day with horror, and unsparingly, if not universally, condemned. He was looked upon as an advocate of lawlessness, as the uprooter of the foundations of society; and his wife — that remarkable woman, Mary Wollstonecroft—holding, among other peculiar views, that marriage was a pernicious institution, was considered as an emblem of all that was unwomanly. The "Political Justice" appeared in 1793, and its author died in 1836—not so very long ago. But what a change since then has taken place! What is thought of Godwin's writings now? No one condemns their socialistic tendencies, or regards them with horror, or deems them dangerous. On the contrary, his views and opinions, with others of a far more advanced kind, are generally discussed in books, magazines, pamphlets, newspapers—are advocated and insisted on by many leading thinkers of the present day, and are talked over with more or less intelligence among the masses in their political and social gatherings. The policy of the present day is to adopt, it would seem, the measures framed by the Ministry of progress in France in 1848. Those measures were as follow: To procure labour for all who are out of employment (and that the French Government bound itself to do by a solemn decree); to transform the Bank of France into a State bank; to control by the State all railways, insurance companies, and savings-banks; to erect public workshops and general stores; to found agricultural societies or companies on co-operative principles, and such-like. We copy very closely these proposals, but no one regards them now as revolutionary. Those that were adopted by the French in 1848 proved in practice unworkable, and were abandoned.

But the world of to-day, not gaining experience or profiting by the lessons of history, takes them up again, and hopes to be more successful than Lamartine's Ministry. These proposals, and the principles underlying them, are viewed more favourably every year, and are steadily advancing, it would appear, in public estimation. Men of note are stirring in the cause: Kingsley, Maurice, and many others, now dead, devoted their talents and influence to its advancement. Ruskin, who values himself upon being a communist of the old school, taking his place among those who regard your property as theirs and theirs as your own, comes to the front in the same cause. He is esteemed and honoured as a great teacher, and well sustains his reputation by his admirable writings. William Morris, poet of the "Earthly Paradise" and other works of acknowledged merit, follows close upon Ruskin's footsteps. He distributes leaflets among the masses containing the principles he advocates, and the plans he has in view for ameliorating the condition of workmen, the better distribution of property,

and the reorganization of society in general. It is the socialism of this poet that I propose to place before you now.

In "Socialism: its Growth and Outcome," by William Morris and E. Belfort Bax, the subject is dealt with, they tell us, from the historical point of view, a continuous though slight sketch being given of its development in history. The plan of the work also deals with the aspirations of socialists towards the society of the future. As it is further stated that each sentence has been carefully considered by both authors in common, I shall deal with their statement of the life of the future as if it had been penned solely by Mr. Morris. His views appear under the title "Socialism Triumphant," and I propose to give an outline of his scheme, though by no means either a full or complete one.

As barbarism gave place to civilisation, so Mr. Morris believes there will be a transformation of modern civilisation into socialism—a socialism which would deal primarily with *the administration of things* and only indirectly with *the government of persons*. Civil law, based on private property, would cease to exist; and criminal law would tend to become obsolete. As to the machinery by means of which the administration of things would be carried on, the federal principle would, he thinks, assert itself, developing into a complete automatic system, the work of the higher circles being performed by delegates.

The religion of socialism will be but the ordinary ethics carried into a higher atmosphere, and will only differ from them in degree of conscious responsibility to one's fellows. Socialistic ethics would be the guide of the daily habit of life; socialistic religion that higher form of conscience which would impel those guided by it to actions on behalf of a future of the race such as no man could command in his ordinary mood.

In life under the socialistic order marriage would not be on the basis of a lifelong business arrangement, but on mutual inclination and affection, an association terminable at the will of either party; and he says (I give the sentence in his own words), "It is easy to see how great the gain would be to morality and sentiment in this change." Property in children would cease, for they would have all the advantages of citizenship, and would be cared for and by the citizens.

The occupations of mankind would be accompanied by pleasure, as every successful exercise of energy should be. Commercialism kills all art for the workman. Fourier's assertion that all labour can be made pleasurable under certain conditions is adopted. These conditions are, briefly: Freedom from anxiety as to livelihood; shortness of hours in proportion to the stress of the work; variety of occupation if

the work is of its nature monotonous; opportunity for every one to choose the occupation suitable to his capacity and idiosyncracy; and, lastly, the solace of labour by the introduction of ornament. Architecture, he thinks, will be the act of a society of co-operatives; sculpture and pictures part of a fine building, turning a utilitarian building into a great artistic production. The buildings would probably be so large as to be almost small towns in themselves. As to literature, he thinks the novel, and fiction in general, would die out; but not the great art of poetry, which has changed so little in essentials since the Homeric epics. Science, he asserts, will be free, and not the servant of profit-making industrialism. Music will develope completely new styles of its own no less than the other arts, and music and architecture be the serious occupation of the greatest number of the people. In costumes the extreme difference between the garments of the sexes would probably be done away with. Education would make the best of each individual's powers in all directions, to which each would be led by his innate disposition.

Under these conditions man would lead a life of happiness without imputing it to himself for wickedness, a habit of mind which, under the prevailing ethical ideas, casts a gloom over so many. In all this, Mr. Morris says, he has at least tried to make his belief clear; he is convinced that the kind of life he describes (which he can foresee) means general happiness for all men, free from any substratum of slavery, and he is equally convinced it will be forced upon the world.

This is, very briefly, Mr. Morris's scheme for the re-arrangement of social life. He has evidently bestowed much pains upon it, is thoroughly in earnest, and honestly believes it will confer universal happiness upon mankind. We have no reason to doubt the pureness of his motives or the sincerity of his convictions—convictions, be it remembered, of a man of no mean order, earnestly intent upon benefiting his fellow-man. His social scheme therefore claims and deserves our best attention.

On perusing his "Socialism Triumphant" we are led to ask ourselves, Is this real or dream life—a social arrangement fitted to benefit mankind, or a "poet's vain imaginings"? To enable us to answer that question in a satisfactory manner, we must recall what we have read on the subject of socialism and communism, and in doing so there will be found, I think, in all their proposals and theories for the universal happiness of mankind a great similarity. Let me call your attention to one or two prominent features characteristic of all such schemes. A great writer (Hume) has said, "All

plans of government which suppose great reformation in the manners of mankind are plainly imaginative." This is very applicable, as will be evident if you take the trouble of comparing the social schemes elaborated and put forward, in all earnestness of purpose, by such theorists as Saint-Simon, Fourier, Lassalle, Karl Marx, and other German, French, and English socialists, with those which are admittedly imaginative—such, for instance, as Moore's "Utopia," Lord Bacon's "New Atlantis," Campanella's dream founded on a superior moral basis, the flying people of Peter Wilkins, Johnson's "Rasselas in the Happy Valley," and works of that class. They all alike lead us into a region far removed from the earth, where the visionary preponderates, if it does not, indeed, reign supreme.

Another feature marking very clearly the imaginative character of these schemes is the sudden, not to say miraculous, reformation or transformation of human nature, by assuming that every one is equally good, of equal capacity—mind and body—and by eliminating all selfishness and self-seeking from individuals. And this characteristic is further evidenced by the wondrous facility with which the transformation is effected. Reformers deem it only necessary to say, "Just substitute 'servant' for 'master'; make poverty wealth and wealth poverty; unloose man from overt and covert be; and straight out of social confusion true order would spring." Nothing more need be done. The transformation is complete.

Another general feature which it is painful to observe in the majority of these social schemes, from Plato to Mr. William Morris, is the determination on the part of the propounders to degrade women to the utmost. The domestic tie is to be severed, domestic virtue ignored, the love of offspring destroyed, and women reduced to mere generating-machines. "By two tests," says De Quincey, "is man raised above the brutes—First, as a being capable of religion (which presupposes him a being endowed with reason); secondly, as a being capable of marriage." These capacities meet with no recognition at the hands of social reformers. We do our best to ignore the one, and the other is, as a natural consequence, adversely affected. The number of marriages in some communities where religion is little thought of or respected becomes lessened considerably.

The persistent dream of universal happiness is a singular and most interesting phase of human thought. It exercises over most minds a very fascinating influence. Men are for ever seeking a region where "all that poets feign of bliss and joy" may be realised in this world. But these dreams are only prismatic-hued pictures of restless imaginations, moved

thereto in nearly all cases by a contemplation of the miseries of life and an ardent desire to ameliorate its adverse conditions. Poets who have given us many such pictures are the first to point out the difference between the ideal and the actual, the real and the visionary. They are not deceived by their own compositions, nor do they wish to deceive their readers. They tell us plainly that the Eldorado sought will never be found on earth, that when men dream of some age in *this* life in which evil is subdued and right and good become universal they are in error, pursue phantoms, and miss the true meaning and intent of life. Strange to say, Mr. Morris himself comes apparently to some such conclusion. In his opening poem, in the work already referred to, he gives a pathetic account of certain men who set sail to find the earthly paradise, and after many years of wanderings, hardships, and (to some of the number) death, came when very old men to a far land, told their tale, and asked leave to die there. Mr. Morris says, speaking in the character of the wanderer,—

> Masters, I have to tell a tale of woe,
> A tale of folly and of wasted life,

and this, I take it, will be the sad experience of any who may be induced to adopt the plan of life shadowed forth by Mr. Morris in his "Socialism Triumphant." But let us assume that it is established on his own basis. What then? Life would stagnate and become listless,—

> Quiet as Carmel, where the lilies live.

But is this animal life? In the cells of the animal body there is, physiologists tell us, ceaseless activity. Every orb in the universe, every atom of the earth, tell the same tale. "Nothing *there* is motionless." How can man with his infinite desires be content? He is restless ever; and when these reformers seek repose and a dreamy kind of happiness as the highest good attainable in this life they fall, it appears to me, into a fatal error.

If I am correct in the view I have taken of these several schemes—and I am inclined to think that I am—then high ideals are delusive, and of little practical use in real life. They are not adapted to perverse human nature, ill accord with what we know of business realities, and cannot be accepted as precedents without the gravest responsibilities being incurred. Our place is in this world as man, we must remember, and nothing more—

> Man who, as man conceiving, hopes and fears,
> And craves and deprecates, and loves and loathes,
> . . . . Till death touch his eyes.

And with this we must be content, for we cannot alter life, do what we will.

There are a certain number of radical reformers whose principles, were they allowed to prevail, would spread ruin and desolation everywhere. They aim at subverting the existing social system in order to reconstruct it in their own way. Karl Marx and his disciples make no attempt to conceal the object they have in view, or the means by which it is to be attained. It has been often said, "Money is the source of all evil; alcohol the cause of all crime," but these wild reformers declare that "Private property is the mother of all crimes." This is the very frenzy of democracy. They declare also that "Society must be destroyed," individualism suppressed, and an association of mankind take its place. They look to a violent subversion of existing order, and propose to appeal to force to establish the rule of the labourer. Would this rule, if established, confer any benefit upon mankind? It is more than doubtful. The stately pyramid of social order, reared and fashioned by the best exertions of the most capable men of all times, is to be torn down for the purpose of being reconstructed in another form, not as yet generally decided upon. Destruction and reconstruction are easily said. Let us for a moment take it for granted that these worthies have completely succeeded in destroying by violence the existing social order. What follows? The material of the pyramid, human nature, though severed and scattered, still remains the same. Those who previously formed the broad base upon which the structure rested have now the power of altering its foundation. How will the material be used, and what form will the reconstruction assume? Some of the very advanced thinkers have settled a plan on the following lines: "Abolition of money, inheritance, and private property; restriction of the isolated household, and development of the associated home; freedom of sexual unions; compulsory and equal sharing of all physical labour, and equal division of the means of existence and enjoyment; universal diffusion of education, science, and art." Now, however we may sympathize with the last-enumerated demand, reasonable men must oppose to the utmost the remainder of this destructive scheme.

Art. XLVI.—*Problems of Arctic Exploration bearing upon Recent Attempts to reach the North Pole.*

By H. Hill, B.A., F.G.S.

[*Read before the Hawke's Bay Philosophical Institute.*]

It would be useless to enumerate the expeditions that have set out to learn something of the land or lands which are within the bounds of the arctic circle, but more especially as to the spot which is geographically distinguished by the name of the north pole. The information which has been gathered as to the climate, currents, animal and vegetable life are of great value and interest to science, but these are even of less importance than the information that has been collected with respect to the past plant-life that must have existed in those inhospitable regions. I do not know whether anything of special value is to be gained by reaching the spot to which so many eyes have been turned for a long time past, but until success has been attained we may expect the devotees of science—if the travellers to such a place may be so termed—to strive by every means to reach the goal of their ambition. Many lives have already been sacrificed, but the ardour is still strong among the nations, and not long ago a novel expedition started from Spitzbergen in the hope of reaching the pole in a balloon.

The expedition is made up of three Swedes, named Andrée, Eckholm, and Strendberg, all ardent scientists and specialists. Andrée is the leader of the expedition, and he hopes to reach the pole in a balloon which has been specially constructed under his immediate supervision. The balloon was made in Paris, and is composed of three thicknesses of silk firmly glued together, the outside being covered with no less than five coatings of varnish. The balloon is enclosed in special netting, and from the suspension-ring there hangs a curiously constructed basket resembling a gondola. Here the adventurers are to live, and many curious arrangements and contrivances have been provided for the convenience of the travellers, and for the storage of provisions, instruments, and such other things as are considered needful for the requirements of the expedition. The balloon itself is 75 ft. from summit to mouth, and to the bottom of the basket 97 ft. The basket has a depth of about 5 ft., is circular in shape, and has a cover or lid made of wicker-work. The basket is provided with a single bedstead, the arrangement being such that one will sleep whilst the others are on duty. A special

apparatus has been devised whereby the party will be able to cook their food, the apparatus for this purpose being let down for 15 ft. or more below the basket. The apparatus will be lighted by simply pulling a string, and when the cooking is finished the fire will be put out by the pulling of another string. These precautions are deemed necessary to insure the safety of the expedition. The total weight of the balloon, with occupants, appliances, and food, will be about 5 tons.

One of the most interesting things in connection with the expedition is the letter which has been issued by the Russian Government to the people of North Russia and Siberia directing attention to the possible arrival of a balloon and its occupants. Drawings acccompany the letter, and the people everywhere are enjoined to render every help to the strangers to get out of the basket in safety, "for the air-globe cannot harm even small children." Should the globe be seen the people are to notice the time, the direction of its flight and of the wind. Finally, the people are exhorted not to be frightened by the globe, but to help the men in every way in their descent from the sky to the ground, and they are to do this "for the good and merciful God and the mighty Czar."

The expedition left Gothenburg in the ship "Virgo," and was to proceed to Tromsöe, in Norway, near latitude 70° N., and a few minutes westward of the 20th meridian east of Greenwich. The ship was then to proceed with the party to Spitzbergen, and there the necessary preparations were to be made for the inflation of the balloon. I am sure every one who takes the least interest in science, and especially geographical, geological, and meteorological, must wish the expedition every success; but, for my own part, I think it must end either in failure or disaster. My reasons for this opinion will appear in the course of this paper.

One important point in favour of the expedition is the fact that the work will be carried on at the best season of the year in the "land of the midnight sun," as from the time of the arrival of the voyageurs at Spitzbergen, which they were expected to reach about the 20th of June, the sun must appear in the sky at an elevation varying from 33° at meridian to 13° at midnight. This will be of immense advantage in the matter of observation within the area which separates Spitzbergen from the pole.

The special difference between former expeditions and that headed by Andrée is in the means employed to reach the desired goal. As far as is known, the Arctic Ocean for the greater portion of the year is a mass of ice, and certainly

there are large areas of it which are constantly frozen. Nordenskjold, in his "Voyage of the 'Vega,'" speaks of five varieties of polar ice as occurring in the Arctic Ocean, and it may be taken for granted that the area within a few degrees of the pole is ice-bound the whole year round. The limited communication between the Arctic and Pacific Oceans is such that comparatively little heat is carried from the latter to the former by means of currents, the only communication between them being by way of Behring Strait, which in its narrowest part, between East Cape in Asia and Cape Prince of Wales in America, is barely forty miles wide. No doubt much heat is carried by means of currents from the Atlantic, but there are physical conditions in operation within the circumpolar area which it will be necessary to consider in this connection.

Dr. Nansen's route to the pole in the "Fram," in which undertaking he has been to a large extent successful, was to follow along the northern shores of Europe and Asia as far as 130° E. of Greenwich, then turn north-east until 150° of E. longitude is reached, then proceed due north in the direction of the pole, and, crossing the meridian of Greenwich between latitude 87° and 88°, return to Europe by way of Jan Mayen Island. Nansen's theory was that a warm current passes along the north-west of the New Siberian Islands, and trends in the direction of the pole, meeting the Atlantic currents somewhere between Spitzbergen and Greenland. This theory he based on the circumstance that portions of the American ship "Jeanette," which was crushed among the ice-floes in 1881 near the New Siberian Islands, were found three years afterwards by some Eskimo on the east coast of northern Greenland. Nansen's return under great hardships and the return of the "Fram" fully bear out the truth of this surmise; but it appears to me that the whole of the polar area between 85° and the pole can be nothing more than a mass of surface-ice, and that whatever movements take place in the waters below they are necessarily very slow, owing to the equability in the temperature of the waters at all depths.

Under the most favourable conditions it is only for a very short period that the seas known at Barent's, Kara, and Nordenskjold, to the north of Europe and Asia, are free from ice. Nordenskjold, in his celebrated voyage, was forced to go into winter quarters on the 28th September, 1888, and it was not until the 18th July of the following year that he found the sea sufficiently free from ice to enable him to proceed. At that time his ship was in latitude 67° N., or 23° from the pole. Now, the ice towards the pole was still a compact mass, and as far as is known there is no land in the line between

Behring Strait and the pole. This vast area has little communication with the warmer oceans towards the south, and, enclosed as it is almost like an inland sea, there is every possibility that the movements of the waters are the reverse of what they are in the warmer oceans, owing to the fact that within the torrid and temperate zones the waters diminish in temperature from the surface downwards, whilst within the polar zone the reverse is the case—that is, the water increases in temperature from the surface downwards.

It is difficult to understand how the area surrounding the poles can be other than the coldest portions of the earth's surface, as it is there that the heat of the sun is least throughout the year. At no period of the year does the sun reach an elevation of more than 23½° above the horizon, and if we suppose the polar or circumpolar area to extend to latitude 80° N., the highest elevation of the sun, then, will not exceed 33½° at the time of meridian, whilst at midnight in summer the elevation will be 13½°—in other words, the sun's elevation during the northern summer will vary within the circumpolar area between 13½° and 33½°.

Let us compare this with the elevation of the sun in the latitude corresponding with Napier during the course of a year. In summer the highest elevation is reached on the 21st and 22nd December, when the sun is on the Tropic of Capricorn, or 23½° to the south of the equator. The latitude of Napier is about 39½° S., so the sun will appear to us about 16° to the north of our zenith, or at an elevation above the horizon of 74°. In winter the sun's elevation at midday will be 27°, or 47° lower than at midsummer. This will be on the 21st and 22nd June, when the sun is at the Tropic of Cancer, or at the time of highest elevation over the Northern Hemisphere.

Now, the period of sunlight within the circumpolar area is equal to that within any other similar number of degrees of latitude. Everywhere there are on the average twelve hours of sunlight for every day of the year; but the question to be considered is not one of light, but of heat. The earth depends on the sun for its heat, and, whilst both heat and light are derived from the sun, the intensity of the one and the quantity of the other are very different in the different zones. The heat-rays from the sun are diffused wherever light penetrates, and, as far as we know, every object in space must receive some of those rays in a greater or less degree. The nearer the object to the direct influence of heat and light the greater we may suppose is the intensity of heat-rays and light-rays upon it, but it will be manifest that the quantity of heat and light received may be modified greatly by the shape of the object. In any case, a source of light and heat acting

on an object from the outside cannot affect that object as a whole under exactly the same conditions, whether the object be moveable or the reverse. The sun acts on the earth daily, and, indeed, momentarily, but each moment a different portion of the surface comes under the influence of the sun's rays. The circle of illumination to-day on the earth's surface, though the same in size or bigness as it was yesterday, is not the same in position, and to-morrow's circle will be different from to-day's. The angle of incidence of the earth in relation to the sun varies every moment as the earth moves in its ecliptic round the sun. Were the earth to present a vertical plane surface to the sun the same number of heat-rays would fall equally over each degree of latitude. Everywhere the rays would reach the earth at the same incidence, and, coming from the same source, the same surface temperatures would result.

But this is what does not take place. The earth's surface is rounded, and during its revolutionary movement about the sun a special area of it is constantly being brought within its immediate influence. This area is the torrid zone, and it is this area that receives, space for space, more rays than any other portion of the earth's surface, for the nearer the area to the torrid zone the more heat-rays are received from the sun compared with any similar area more remote. Thus the circumpolar area, if compared with a similar area within the torrid zone, would receive much less heat from the sun, owing to the absorption of such rays by the atmosphere. Within the torrid zone the estimate is made that about 8 per cent. of the heat-rays which would otherwise reach the earth are absorbed by the atmosphere on their way, whilst 83 per cent. of heat-rays are absorbed within the polar and circumpolar areas. In other words, taking area for area within the torrid and frigid zones, about 92 per cent of the heat-rays from the sun fall upon the surface in the former, and only 17 per cent. in the latter. The results under such conditions must necessarily produce wide contrasts in the physical conditions existing, more especially in the case of moving water and the water-products, rain, ice, snow.

The temperature of the waters within the torrid zone may be set down at 80°, for, according to Wharton, it is 78° in the Atlantic and 82° in the Pacific, whilst the temperature within the frigid zone is certainly less than 32°. Curiously, below 800 fathoms the temperature is never more than 35° in the torrid zone, and may be set down at 30° in the frigid, although recent tests show that a higher temperature prevails than this, even at 2,000 fathoms, in the Arctic Ocean. The argument, however, which it is desired to enforce is not affected thereby. The difference in temperature of the

surface-waters within the warm and cold oceans respectively has a range of 50°, whilst the range of temperature between the waters at great depths in the same oceans is not more than 5°. It is curious and important to notice how the surface- and depth-temperatures of the waters tend to approximate each other in proceeding from the equator to the poles. The surface-temperature at the equator is 80°, and within the arctic circle 32° or lower, whilst at 800 fathoms the temperature falls to 35° at the equator, and to 30° or more within the circumpolar area.

It follows from these facts—first, that surface-movements of the waters of the ocean are greater than depth-movements; and, second, that depth-movements in the warmer oceans are much more pronounced than within the cold oceans. These laws have an important bearing upon the past and present condition of the earth's surface, as it must be evident that these conditions have not always existed.

I have purposely dwelt on this interesting topic at some length, as it is highly suggestive in connection with the nebular theory of the earth, as it is also in the matter of aerial movements. No one who considers the nebular theory as bearing on the life-history of the earth but must be struck with the harmony of the records that have come to us through the brave men who have striven to solve the mystery of the north pole. Those records imply a great past in the life-history of the now frigid zone, but they also imply a growth, a development, and a descension. The time was when the life-possibilities in those inhospitable regions were greater than they are now, and the question must be asked how the changes in activities have been brought about. I think it may be assumed that the depth-movements of the ocean were much more pronounced in former times than they are at present, for the waters were then heated more by convection than by conduction. When the earth was many degrees warmer than now the surface-contrasts were not so wide, and, as a consequence, surface-movements, like currents which are produced by heat, were not so pronounced.

Let me illustrate what I wish to convey by means of two simple experiments. First, take a bottle—an ordinary water-bottle will do—and fill it about one-third full with water at a temperature of 60°, the water being slightly coloured with a blue tint. Let this be followed by a similar quantity of water tinted red at a temperature of 100°, and then fill up with boiling water having a green tint. In the second experiment reverse the order of filling the bottle by putting in the boiling water first, and then observe the results in each case. In the first illustration the movements of the water will be com-

paratively slow, because water at 60° is denser than at 100°, and at 100° than at 212°. Water heats slowly by conduction, and the tendency is to move as a surface-water in the direction of the boundary where the temperature is least. In the second bottle the hottest water at the bottom is less dense than that at the top, and they are in a condition of unstable equilibrium. The movements here must be up and down rather than up and horizontal. These two examples illustrate the movements of the waters of the ocean as I conceive them in times past and present.

Surface-movements are greater now than they were in former times, whilst the reverse is the case in the matter of depth-movements. But the surface-waters as they proceed from the torrid zone outwards are constantly parting with their heat, and as the waters as currents approach the colder zones they also approach the depth-temperatures of the waters in those zones. Were the waters of the earth of the same temperature and density there would be no current-movements either vertical or horizontal, and were the earth's surface a plane vertical to the ecliptic there would be no horizontal movements of the atmosphere—that is, there would be no winds, as no other movement would be possible but one at right angles to the surface, or what, in other words, might be termed an up-and-down movement. And this brings me back to the water and air oceans within the torrid zone. That portion of the Arctic Ocean which is embraced within the circumpolar zone extending from 5° to 10° may be supposed to be almost free from currents, owing to the fact of greater density combined with the circumstance of the near approximation in temperature of the surface and deep waters. Whatever movements there may be must have a tendency downwards, and thence in the direction of the warmer areas; for it must be remembered that the waters of the frigid zone are not now fully maintained by the quantity of solar heat given to that zone, but rather by the surplusage that finds its way to the frigid zone from the other zones by means of aqueous and atmospheric agencies. Thus, for example, the movement of waters from the Pacific and Atlantic Oceans towards the colder zones is an important means of conveying heat, but the same thing may be said with respect to the large rivers that pour their waters into the Arctic Ocean from Europe, Asia, and America. These warm areas of inflow occupy cardinal points with respect to each other on a map of that ocean. Thus, Behring Sea is opposite to the opening into the Atlantic Ocean, and the great Mackenzie River may be set down as being opposite the Obi and other large rivers of Asia.

Warm areas were specially noticed by Nordenskjold, and

it was through the channels of partially fresh water that he pushed his way along the Asiatic coast. The question is whether these warm areas from the rivers tend to form currents in the direction of the pole, and whether they supply some of the varieties of ice which are mentioned by Nordenskjold as occurring along the margin of the ice-pack in the Arctic Ocean. Fresh water freezes at a higher temperature than salt, and it may be that, as the fresh and warmer water of the rivers pushes northward, an open water-way may be produced in summer in the direction of the pole; but it is impossible to suppose that the movements can be regular and continuous, seeing that the physical conditions are undergoing seasonal modification both with regard to ocean- and river-waters.

Now as to aerial conditions: These, it appears to me, are even less favourable to a successful voyage to the pole than the oceanic. During the time that the "Vega" was wintered in latitude 67° N. the temperature fell as low as 45·7° below the zero of centigrade, and for months it appears that the cold was more severe than anything experienced in more southerly latitudes. But this low range of temperature, we may suppose, would be greatly exceeded by ascending in a balloon over the areas where tests were taken. Within the tropics an ascent of less than 20,000 ft. brings us to the conditions of an arctic climate, but it would be difficult to say what temperature would be probable at an elevation of 2,000 ft. above a spot where the thermometer showed 46° of frost, centigrade.

Andrée and his fellow-passengers held that they could regulate their balloon so as to keep within 400 ft. or 500 ft. of the surface. But the cold even at this moderate elevation would be likely to increase in intensity as the pole is approached, and it is doubtful whether life could be sustained within the polar area at an elevation of some hundreds of feet above the surface. It has been pointed out how the ocean temperatures at great depths tend to coincide or approximate each other in all zones, but the same thing takes place in the atmosphere, with this difference: that we know absolutely nothing as to temperature for heights beyond 40,000 ft. Suppose, however, that an imaginary line is drawn from an elevation of 20,000 ft. at the equator to the sea-level at 80° of north latitude, it would represent roughly the descending line of corresponding temperature in the atmosphere, or, say, the freezing-point on a centigrade thermometer. Now, it will be manifest that, if the freezing-point at the equator, or within the tropics for that matter, is constant in the atmosphere at an elevation of 20,000 ft., and the freezing-point in the shade is constant at 80° N. latitude at the sea-level, just as in the

water there is a tendency to equality of temperature which becomes coincident at certain depths, so the same tendency is met with in the atmosphere, and apparently becomes coincident within the polar area.

Air is but slightly heated by the passage of the sun's rays through it, but when the heat has reached the earth's surface the air becomes heated by contact. It then expands, its density is less, and, as a consequence, it rises. The direction of the movement is either vertical or vertical with a horizontal tendency, and just as the water movements are regulated as to rate and direction by the differences or contrasts in temperature, so the aerial movements are regulated in a similar manner. The deep waters in the temperate and frigid zones might be expected to move towards the warmer areas exactly in accordance with the characteristic temperatures of the waters of the ocean at all depths, just as was shown must occur under the conditions named in the examples quoted. The vertical height of the snow-line diminishes as the polar region is reached, it being regulated by the amount of surplus heat available in each zone. The temperature scale from the equator is a descending one between it and the pole, whether that scale be taken on the surface or at any elevation whatever above the surface. If the surplus heat which is supplied to the different zones were to be equalised by atmospheric distribution as it passes away by radiation into space the same atmospheric temperatures would result, but the very fact of there being atmospheric differences of temperature at the same elevation in the several zones shows that the heat-rays which are emitted from the surface in each zone are mostly, and perhaps wholly, used in the zone where such rays reach the earth.

Scales of temperature can be drawn at any parallel of latitude to represent a vertical and horizontal measure of heat, but the alteration of temperature in the vertical scale is much more rapid than in a horizontal one; but this could not be were the heat from the earth's surface conveyed by the atmosphere in a horizontal rather than in a vertical direction with a slightly horizontal tendency. In connection with these scales representing vertical and horizontal temperatures it is needful to keep two things clearly in view—first, the barometric pressure on the earth's surface may be said to be the same for all degrees of temperature between the equator and the polar area; second, the pressure of the atmosphere at freezing-point varies from the equator to the polar area from 15 in. at the equator to 30 in. within the frigid zone—in other words, freezing-point at the equator would be at 20,000 ft. elevation and a barometric pressure of about 15 in., whilst within the polar area freezing-point would be at sea-level, and

the barometric pressure at 30 in. or more As in the case of water, the atmospheric temperature has a wide range or contrast at the equator, and constantly diminishes its range as the poles are approached. We have no means of knowing what the temperature in the atmosphere would be at an elevation of 20,000 ft. above the polar area, but certainly it would be so low that life such as we are acquainted with could not exist there.

Each of the zones has a certain quantity of heat-rays available, and no more, and when those rays have done their work on the surface, whether on the land or on the water, they tend to pass back again through the atmosphere, and are subsequently diffused in space. But the work which is performed by the returning obscure rays in either zone appears to be directly proportional to the radiant heat received from the sun by the zone. And the varying height of the snow-line from the equator to the polar circle seems to suggest the truth of this statement. When the air within the torrid zone ascends, laden as it is with moisture and heat, it has a definite work to perform within the atmosphere of that zone. The difference of elevation in the snow-line of each zone represents the total surplus heat which the atmosphere of the zone has been able to perform owing to the excess or deficiency of heat-rays in the zone compared with the adjacent zone, and I am doubtful whether the heat taken away from a zone by ascending currents is greater than the heat received in the same zone by the incoming currents. Suppose, for example, that the temperature of the torrid zone were increased by 20°, what would be the atmospheric effect on the other zones? Aerial movements would be more rapid; evaporation would increase; heavier rainfall within the tropics would ensue; the elevation of the snow-line would be raised; and the seasonal contrasts between the several zones would be more marked than they are now. Of necessity the winds would increase, but the balance would be maintained between lower incoming and upper outgoing currents, no matter what modification in the temperature might take place.

It has already been explained how wide the difference is between the heat-rays received in the different zones, and when it is remembered that the capacity of the atmosphere for moisture, other things being equal, depends directly upon temperature, it will be seen at once that the vapour from the torrid zone can hardly reach beyond the limits of its own zone, as evaporation in each zone will continue everywhere until saturation-point is reached, or, which amounts to the same thing, the natural tendency in each zone is to satisfy the atmospheric and aqueous conditions under the constantly modifying factor of heat. Thus air of high

temperature and density has a high capacity for aqueous vapour, but these conditions are never met with in combination within the arctic zone, while they are constant within some portions of the torrid zone. If we apply these facts to the distribution of heat on the earth's surface it will not be difficult to understand the intensity of cold experienced by arctic voyagers, for, though movement is constant in the water and air oceans, the general effects produced by the movements are very small outside each zonal district or centre. The trade winds, monsoons, and, in fact, winds of all kinds, are the outcome of differences of atmospheric temperature. As we approach the polar regions the contrasts of temperature grow less and less. The temperature being low, the vapour or moisture in the atmosphere is also low.

It is a curious thing that Nordenskjold, in his "Voyage of the 'Vega,'" makes no reference to rain during the period of his wintering in the Arctic Ocean, although he appears to have paid much attention to the weather. In vol. i., p. 482, the following reference occurs: "The weather during winter was very stormy, and the direction of the wind nearest the surface was almost constantly between north-west and north-north-west, but above there appeared an atmospheric current uninterrupted from the south-east. This when it sank to the surface brought with it air that was warmer and less saturated with moisture."

A similar remark applies in the case of Dr. Kane. I do not remember a single instance in which he records the falling of rain during his long stay within the arctic zone. In vol. ii., p. 55, reference is made to "that strange phenomenon the warm south and south-east winds, which came upon us in January and did not pass away till the middle of this month. And even after it had gone the weather continued for some days to reflect its influence. The thermometer seldom fell below − 40°, and stood some times as high as − 30°." Further on Dr. Kane says, "There is much to be studied in these atmospheric changes. There is a seeming connection between the increasing cold and the increasing moonlight, which has sometimes forced itself on my notice." The valuable tables of temperature which are given by Dr. Kane (vol. ii., Appendix xii., p. 415) show the remarkable contrasts of temperature which are met with in high latitudes. For the year 1854 the mean temperature of the air was − 5·01°. The highest temperature experienced was on the 4th July, when the thermometer registered 53·9°. The minimum temperature was reached on the 5th February, when − 68° of cold was registered; thus the range of temperature experienced in latitude 78° N. was 123·20°.

I have not Dr. Nansen's "Journey across Greenland" at hand, but I do not remember any reference made to rain in his remarkable journey. Snow-storms were not uncommon, but of rain there was none.

I have purposely quoted these facts to show that the climatic conditions as tested by different travellers go to prove how small must be the benefits derived by the cold zones from either the torrid or temperate, by means of currents and winds.

The water of the torrid zone is of an average temperature of 80°, and this is maintained directly from the solar heat received. Of the solar rays which reach the earth most of them are used to maintain the temperature of the zone—in fact, the heat of each zone may be said to be directly proportional to the number of heat-rays received by the zone, just as the amount of aqueous vapour in each zone is proportional to the temperature, other things being equal. The conditions which seemingly exist within the polar area are opposite to the conditions which prevail in warmer areas. The surface-water or ice is colder than the stratum immediately underneath, and it seems that the movement would be downward with a southerly tendency, and that this form of motion is necessitated by the fact that the incoming waters, instead of being heated, are actually cooled as they move poleward, whilst the several strata of underlying waters are forced to move southward awry to supply the place of the lower areas which are constantly moving towards the equatorial regions. In the same way the atmosphere within the polar area is very unlike that within the warm zones. The air is dry mostly, as the temperature is not sufficient to maintain much vapour. But dry air is very diathermanous, and heat is transmitted through it with little or no alteration of temperature. Here we have physical differences existing in the warm and cold zones, and these differences are such that they require the closest attention at the hands of scientists.

As to temperature, direction of winds, the existence of animal life, the possibility even of living in the air under the conditions proposed by Andrée, very little is known. Neither Nansen nor Andrée, I am afraid, will reach the pole, at least if the conditions such as I have suggested above actually exist within the polar area. But, whatever may be the results of Andrée's enterprise, there can only be one wish for the brave men who have started on such a romantic and hazardous voyage. They carry their lives in their hands, for they may be stranded on ice-fields, with no power of getting rid of their difficulties. With dogs, sledges, and snow-shoes Nansen was able to cross Greenland, but he was sure of ice or land for his journey. Andrée and his companions have no

boat, and no means of returning should any accident befall their balloon by the way. And even should fortune's wind waft them to the pole they dare not allow their craft to fall. Well might the circular that has been issued to the Russian people on behalf of the expedition urge those who might see the balloon "not to be frightened by the globe, but to help the men in every way." Whether they succeed or fail, all must hope that they survive to tell of their experiences in a lifeless world of ice and cold—a world that once was as active as our own, and which offers a type of what the temperate and torrid zones will be in the ages that are to come.

[NOTE.—Since this paper was written the news has come to hand that Andrée's project had probably ended in failure, and that Nansen had returned, after reaching beyond the 85th parallel of north latitude.]

ART. XLVII.—*Are they Old Kumara-pits?*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute.*]

ON Mr. Graham Speedy's property, near Herbertville, Hawke's Bay, are seven right-angled pits, some 18 in. or 2 ft. in depth. They are on a small, narrow piece of land mostly surrounded by a sloping incline 16 ft. in height. At first I hoped they would prove to be the remains of ancient sunken or pit dwellings, such as those found near Pelorus Sound, and said by some persons to have been occupied by a pre-Maori people; but from the narrow width of my seven pits they must be other than original sites for dwellings. Therefore I conclude that these pits are where the esculent kumara has at one time been stored. The longest pit is 22 ft. in length by 8 ft. across; another is 14 ft. by 6 ft., and others are 6 ft. by 10 ft., 10 ft. by 5 ft., 18 ft. by 7 ft., 13 ft. by 6 ft. The excavations are still fairly square in the angles, and have perpendicular sides. The width of those only 6 ft. across would prevent a man from sleeping across the space in Maori fashion; so we may conclude that here was an old-time storage-place of the Maori crops. I remember, many years ago, seeing a row of such pits, near the road-side, between Moteo and Omaha, in a sand-ridge running parallel with the river. But about or near these pits were scattered shells, the remnants of Maori feasting; and I have no certain remem-

brance of the length or breadth of the pits. Certainly the remains of former shellfish feasts gave the locality a home-like aspect.

ART. XLVIII.—*A Maori Stronghold.*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute.*]

THE old-time pre-pakeha Maori and his history, habits, and mode of life are becoming year by year more interesting. I will now, therefore, endeavour to describe some of the evidence still remaining of the works of the old-time Maori people.

About the year 1876 or 1877 Mr. McDonnell, who then owned the land known as Rakamoana, near Pohui, showed me the remarkable position which had been selected by Maori people as a refuge from the attack of others of their race, or possibly as a fortified habitation. The site of this fort is in a bend of the Mangaone River—I may state that this river and its affluent creeks are nearly always on either side embanked by high precipices of papa rock, in some cases several hundred feet in height, and which are in most cases entirely inaccessible and highly dangerous both to animals and man if unaware of their proximity.

This pa was situated on a kind of peninsula, being connected with the main land by a very narrow neck or passage. On either side of this entrance-passage to the pa was a great precipice, and it was easily seen that an assaulting party could only approach it by one or two at a time; it was terrible to think how the combatants might be thrown both to left and right down this frightful chasm, or that champion fighters of both parties might fall over locked in a tight embrace.

The interior of the fort was of considerable extent, and was protected on the other two sides by the cliffs, while the more gradual, though still very steep, descent to the river on the fourth side was protected by a ditch and bank, probably at one time carrying a palisaded fence.

I noticed several remains, still erect, of posts; very likely the remains of whares, or dwelling-places. I also observed several pits which made me think of rifle-pits, but possibly they were store-places for kumara or other provisions.

Water would have to be carried from outside the fort up the long and steep ascent from the river. This want of water within the pa was the common defect of Maori forts, and

must often have caused the besieged party to suffer great torture, and possibly to capitulate or surrender, in which case the conquered warriors would be mostly killed and eaten, and the women and children be carried away as slaves to the victors.

The site of this pa is near a track known as Marshall's Crossing, named after the first European owner of Rakamoana —the Rev. Mr. Marshall, who actually kept a school for boys in this out-of-the-way place.

On questioning some Maori shearers at a later date as to the history of this pa they referred the question to an old man who was employed at the wool-table. He replied in Maori, which was interpreted by one of the others to me in English. The story was this: The dwellers in this pa were relatives of Maoris living at Moteo—a distance of some ten miles. Another tribe of Maoris came one day from the north, by way of Titiokura and Pohui, and, taking the dwellers in the pa by surprise, killed them all or otherwise disposed of them. Shortly after the people from Moteo started on a journey to visit the pa, being unaware of the fate of their friends. As the land in those days was covered with a dense growth of fern, tutu, and manuka scrub, the stony bed of the river was, especially during the warmer months of the year, the easier line to travel. As is the Maori custom, when these travellers neared the pa they commenced to search the likely places for eels, so that they might arrive with a present of acceptable food; and presently they were horrified by seeing the water blood-stained, and further on they came across the dead bodies of some of the people of the pa, which had been thrown over the cliff. Upon this the visiting party fled in the greatest terror.

Art. XLIX.—*A Maori Earthwork Fortification.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute.*]

The site of this remarkable work is close to the small township of Herbertville, and to the south side of the Wainui River. A small but deep and sluggish stream here joins the river, and together they enclose a considerable semicircular space. This partly enclosed piece of ground would seem to have been selected by a party of Maoris as a place of refuge in times of danger, in case of an assault from others of their race with whom they had a blood-feud or vendetta.

It is quite a novelty, I believe, to find that the Maori has defended a position by earthworks the present height of which would seem to indicate that they could never have been surmounted by a palisade of woodwork. As it now stands there is a double wall of earth, having an interval of about 12 ft. between the two walls, and also a broad dry ditch. The outer wall is almost or entirely perpendicular on both faces; it stands 5 ft. in height, and shows signs of a ditch along its outer face. It is now 45 yards in length. The inner and parallel wall is similar, but is 6 ft. in height and 39 yards in length. Neither wall shows much sign of decay, although they leave a considerable space (some 18 ft.) unprotected—from the ends of the walls to the encircling streams. It is possible the walls may have been here eroded in times of great floods, but it is difficult to understand how this could leave the ends of the walls so perfect in condition.

Parallel with the inner wall is a dry ditch, and beyond, but parallel to the ditch, are signs of small square holes, mostly at equal distances one from the other, the object of which I am unable to determine, although they are evidently a particular part of the plan of defence. Is it possible that they represented small pitfalls, by means of which the assaulting party, after negotiating the two walls, might lose their equilibrium? In the event of a warrior, say, landing with one foot on the level surface, the other foot would find no resting-place, and he would fall prone to the earth, and one of the besieged party would then without danger be in a position to crack his skull with a *mere*.

Within the enclosed space are no visible signs of habitation, but there are three small ill-defined pits, which may have been excavated to supply material wherewith to build a portion of the walls. At present the walls have a passage cut through their centre some 2½ ft. in width. I asked an old resident as to this, and he was confident that when first he saw the walls, years ago, there was no such passage. However, I doubt if this be not the original entrance left by the builders, so as to enable cattle to pass, as they could not climb over a 6 ft. wall. At present men and animals can pass at either end of the walls, so that we may suppose this was a wicket-gate for entrance or exit, as the case might be. I was also told that this, and all round, was grown over by ngaio and karaka trees, some of which were 2 ft. in diameter; but nothing of any size can have grown on the walls, or they would have been spoilt or broken down.

Art. L.—*Relics of the First New Zealand Press.*

By R. Coupland Harding.

[*Read before the Wellington Philosophical Society, 20th March, 1900.*]

Plate XXV.

It is well known that the late Rev. W. Colenso was the pioneer of the printing art in this colony. In his little book, "Fifty Years Ago in New Zealand" (1888), he has described the institution of the missionary press, the plant having arrived at the Paihia Mission Station on the 30th December, 1834, and having been landed in the early days of the New Year. He gives a vivid account of the difficulties he underwent through the want of technical knowledge on the part of the under-secretaries of the Mission-house in London, who were above taking counsel with their printer-elect, or, indeed, any other practical man. The result was that many essential articles, including even printing-paper and printers' cases, were omitted, and makeshifts had to be resorted to in the colony, at great expense to the mission. There was not even a composing-stick, "save," he says, "a private one of my own that I had bought two years before in London—a most fortunate circumstance. . . . Fortunately, I found a handy joiner in the Bay, who soon made me two or three pairs of type-cases for the printing-office, after a plan of my own; for, as the Maori language contained only thirteen letters (half the number in the English alphabet), I contrived my cases so as to have both roman and italic characters in the one pair of cases, not distributing the remaining thirteen letters (consonants) used in the compositing of English, such not being wanted." On page 30 he says, "On my coming to reside in Hawke's Bay in 1844 I brought hither with me a small Albion press and types, which I again found to be of great service; though, having a people scattered over a very large district to attend to, with its consequent heavy travelling on foot, there being then no roads, I could not use my little press so much as I wished."

In Mr. Colenso's will he bequeathed to me his little press and all the printing material in his possession, including "type, old and new," and, specially, "my sole composing-stick, with which I did so much work both in England and New Zealand." This material is still stored in Napier. On my visit there this New Year I went over it, and found that certain portions had formed part of the first printing plant, set up in 1835.

For a long time the composing-stick could not be found by the executors. It was at last discovered—alas!—partly embedded in the earthen floor of a damp shed, where it had lain neglected for probably thirty years, and was so corroded by rust as to be almost unrecognisable. Most of the wooden articles had been so ravaged by the boring-beetle that they had to be burnt. An exception, however, was a large and peculiar pair of type-cases, containing the types just as they had been last composed from. These cases were of kauri, and were in good condition. They contained part of a font of small pica, which it was necessary to remove. From their unusual size and depth I took them for "font-cases"—that is, cases specially used for reserve supplies, and too heavy when full to be handled in the ordinary manner; but I had no sooner begun to remove the type than I found them to be a pair of the original cases, made in 1836, from Mr. Colenso's design and to his order, specially for Maori work, and therefore a quite unique relic of the first printing-office. I made a diagram of the cases, showing the "lay," which I afterwards drew to scale, and a copy of which appears on Plate XXV. The cases are $36\frac{3}{4}$ in. long by $16\frac{3}{8}$ in. wide; the depth is $1\frac{5}{8}$ in., the front ledge 2 in.; the bottom $\frac{1}{2}$ in. thick. The upper case weighs (empty) 10 lb. 6 oz.; the lower 9 lb. 12 oz. The cases differ in size, capacity, and slightly in proportion from standard English cases, which are $32\frac{1}{2}$ in. by $14\frac{1}{4}$ in., 1 in. deep, and weigh about 5 lb. each. Both in weight and in capacity they are more than double the English standard. English cases, when well filled, are quite heavy enough for handling, and the Paihia cases would be cumbrous and inconvenient unless always on the frame or stand, as probably they were. The scheme could, however, be reduced to the familiar standard without difficulty.

The problem being given: To design a pattern of case for the alphabetic characters and signs of any given language—no two people would solve it in the same way. And, the plan being fixed, no two people would independently arrange the characters in the same order. It is interesting to see in what a systematic and orderly style our first printer adapted his case to his alphabet. Beginning with the upper case, he adopted the plan in vogue in his youth of placing the capitals to the left. In most modern offices they are now placed, more conveniently, on the right hand. Formerly they were absurdly arranged at the top of the case; he has brought them down, starting with "A" where the modern printer starts, fourth row from the bottom. The Maori alphabetic order is followed: First the vowels; then the consonants, as in English. "G" is at the end, as "G" is properly no part of the alphabet, used only in the digraph "ng," which, in all

phonetic systems, is indicated by a single character. In the lower case the italic letters are arranged in a border to the left and along the top, leaving the handier and larger boxes for the roman. All the cells for italic are uniform in size except for "-p" and "w," which are half as large as the rest. A compositor will recognise that the roman letters, spaces, &c., follow the familiar arrangement of the English case as far as the variation in the alphabet will allow. One or two divisions unmarked in the drawing may have been occupied by minor sorts—there must, for instance, have been a place allotted for the ¶ sign, used freely in the Maori New Testament. Such omissions, however, do not affect the general scheme.

The box above the "H" was marked "Bad letters," and still contained a few damaged types. A French case always has such a box, which is known as the *diable*. In English it is the "hell-box," but is always a separate receptacle. The box over the italic "A" was marked "*h*, old," and contained two italic "b's" with the bottom curve cut off—a makeshift when the supply of "h" ran out. These cut "b's" used as a substitute for "h" may be seen in some of the early mission printing.

It is not likely that it would be found worth while to bring Mr. Colenso's pattern of Maori cases into use, so the originals, which I intend to place, with other relics, in the Colonial Museum, are likely to remain unique. In modern Maori printing little use is made of italic; in the work on which Mr. Colenso was engaged, though the quantity of italic used was not great, words in that character occurred (as in the English Bible) in every few lines. Printers, however, who do much work in the native language would find it advantageous to have a special lower case. The standard upper case, seven boxes by seven each side, would be more convenient than one of six-by-six, as the whole alphabet would come in two rows. To compose any foreign language, and Maori especially, from an English case is inconvenient. The English proportion of "a" is far too small; so with "k," the most frequently occurring consonant, which in English is allotted to one of the smallest boxes. Then, the compositor is cumbered by large quantities of useless sorts, such as "d" and "s," the boxes devoted to which are full and possibly overflowing when the rest of the case is worked out.

Mr. Colenso had sometimes to do English work, and, having no English cases, was put to no little inconvenience. "I may observe," he says, "that such an arrangement proved to be a very good one while my compositing was confined to the Maori language only; but when I had any English copy to compose it was altogether the reverse—then I had to pick out

the discarded English consonants as required from their lots put up in paper parcels. Fortunately this occurred but rarely; except at the time of the Treaty of Waitangi (1840), when I had necessarily much printing-work to do for the Government of the colony, and, having no extra cases, was obliged to place the letters required in little lots on tables and on the floor."

At the auction of Mr. Colenso's sundries large quantities of his old memoranda passed into private hands. Mr. H. Hill, one of our members, is in possession of a mass of these papers, and from him I have a copy of two interesting entries from the old office diary, bearing upon the subject of this paper. They are as follow :—

1836. July 19 —Gave R. Brown, carpenter, Kororareka, an order for six pair cases, one imposing-frame and drawers.

1837. March 8.—Brown's bill for cases, imposing frame, &c., £8 16s.

So far as I can judge, Mr. Brown's charge was reasonable.

Though it does not bear directly upon the first printing-office, I may mention that Mr. Colenso did a great deal of work on his little foolscap-folio Albion press at Waitangi, Hawke's Bay. One book, in Maori, unfinished, was on the lives and deaths of witnesses for the truth in the early Church, written by himself. It was never completed; but he had done about two hundred pages, printed two pages at a time. The amount of labour this represents, in the intervals of an exceptionally busy life, can only be realised by a practical printer. I have the form of the last two completed pages, just as it stood when he left it—either ready for press or printed off. This, I think, is a relic that will be of interest to visitors to the Museum in years to come, as it is set in the old small pica of the first mission press.

The type is of the early "modern" face, probably by Caslon, and is, of course, hand-cast. It must have been cut in the very early years of the century, soon after the abandonment of the "old-face," and before the beauties of the modern style had been developed. It is a heavy, legible, and inelegant style, deficient in "character," and now quite out of vogue. A box of types, small pica and minion, ordered for the office at Waitangi, had never been opened since leaving the foundry until I opened it at Napier, some fifty years after it had been packed. There were indications that Mr. Colenso intended it for an edition of the "Pilgrim's Progress" in Maori—the minion for the notes. He had a manuscript translation which he highly valued. I do not know by whom it was made, and I fear it has been lost. He had also provided himself with stereotype copies of engravings of the fight with Apollyon, &c., to illustrate the book.

I have made repeated inquiries about the final destination of the original missionary plant. The first press is hopelessly lost. One early Columbian press answering to the description was ultimately sold to a foundry in Auckland and melted down; another was shipped to an Australian port, and thence to the Pacific coast of North America—either of these may or may not have been the historic press on which the first Maori New Testament was printed, a relic which would have been highly valued in years to come. I know of yet another old press, which once belonged to the Church Mission, but as it bears date 1841 it is certainly not the first. The large font of small pica, or the bulk of it, after passing through several hands, found its way to Palmerston North, and was used for some years by Mr. Alexander McMinn in printing the *Manawatu Standard.*

ART. LI.—*On a New Species of* Ophiuroidea.

By H. FARQUHAR.

Communicated by the Secretary.

[*Read before the Wellington Philosophical Society, 20th March, 1900.*]

Ophiocreas constrictus, n. sp.

Disc thick, strongly constricted in the interbrachial spaces, concave in the middle, with large, long, prominent radial shields, almost meeting their whole length, and not quite reaching the centre. Diameter of the disc, 22 mm.; length of arm, 470 mm.; height of arm near the disc, 6·5 mm.; width, 7 mm. Disc and arms covered with loose, thick, wrinkled skin, especially wrinkled at the centre of the disc. Skin smooth to the eye, but under the microscope seen to be covered with exceedingly minute papillæ and numerous scattered pores or small pits on the disc and the arms near the disc. The long arms taper gradually to very fine extremities; they are rounded above and flat below. Ribs indistinct. The first two arm-pores have no scales; those beyond have two (rarely three) spiniform, bluntly pointed scales, encased in skin, with rough tips; towards the base of the arms they are rather stout and about equal in size, beyond the inner one is somewhat larger than the outer. The lowermost tooth is stout and bluntly pointed, those above somewhat larger and flattened.

Colour in alcohol reddish-brown above, yellowish below.

This species may be readily distinguished from the other known forms by its very long arms and the small pits in the skin on the disc and arms.

The type specimen which was collected by Mr. W. Docherty at Dusky Sound, and placed in my hands by Dr. Benham for identification, is in the Otago Museum. A dry specimen with its arms coiled around a gorgonian, found by the late Mr. T. Kirk at Jackson Bay, is in the Colonial Museum, Wellington. This is the only species of the family *Astrophytidæ* which has been found in New Zealand waters.

The home of the genus *Ophiocreas* is the "continental slope," all the other known species having been found between 118 and 580 fathoms except *O. abyssicola*, which came from 2,300 fathoms. Our species probably occurs plentifully in the deep water of the fiords on the south-western coast of the South Island.

Art. LII.—*A Hunting Spider.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute.*]

The very large family of predaceous insects known under the title "Arachnida" includes, besides the true spiders, the mites and scorpions. This classification would. to the uninitiated, seem a gathering together of forms which differ very widely one from the other; and so they really do, but at the same time these creatures give evidence of descent from an ancestral Arachnid which was the origin of all these remarkable creatures.

From my own observation certain true spiders are, as it were, a partial copy of the scorpion; they spin no web to entangle their prey, but are provided by nature with a strong pair of arms, terminated by formidable pincers, by which they seize their victim. This pair of scorpion-like arms would seem in a measure to resemble those of the crab, the lobster, and the prawn. They are, in reality, destructive implements, which take the place of the forward pair of legs, and are never used to assist locomotion, but are carried elevated and pointing forward on either side of the creature's head, like a pair of nippers open, and ready for action. The remaining three pairs of legs are solely used in giving movement and stability to the body. The body consists of two main parts—the shorter fore part, to which the pair of claws and the six legs are attached; and the longer after part, or abdomen, which is carried clear of the ground. This dreadful-looking creature, if magnified two hundred times, would be a startling object to meet with in a summer day's ramble, and might lead to undesirable complications. The following account describes their method of catching prey.

Looking at a remarkable spider walking on the window-pane, I became aware that, although seemingly stationary, it in reality was stealthily on the move. This motion would

not have been detected but for a wire netting of $1\frac{3}{4}$ in. mesh, which was stretched across as a protection to the glass. These cross-wires divided the section of the window into numerous small spaces, and by watching closely for a few seconds it became evident that the creature was gliding slowly forward without any perceptible motion of the limbs. The pair of front legs were of enormous thickness compared with the remaining three pairs, which were those by which it progressed when moving. The very strong thick pair were mostly carried projecting forward, and looked somewhat like a great pair of wide-open nippers, which they in reality were, as the sequel will show. Presently a yellow-bodied blow-fly moved into sight, having been hidden by the woodwork of the window-frame. This kind of fly deposits live maggots on meat, &c., not eggs, as do the larger black flies. This yellow fly I never saw in the South Island of New Zealand during a period of some fifteen years, but on coming to Hawke's Bay they were at once apparent from their undesirable attentions. Have these yellow flies since made their way to the South Island, or are they still absent?

To continue my story. As the large fly walked onward the spider moved at about the same pace behind it; on the fly resting the spider became apparently motionless, yet was imperceptibly moving up to its quarry. After some time the space between the two was reduced to about $1\frac{1}{2}$ in., when the spider made a dart forward and seized the fly with its formidable pincer-like legs. One arm was across the head of the fly, and the other grasped the tail, or opposite extremity, while it also seemed to be biting or sucking the life-juice of the insect at its waist or narrowest part. The fly made strenuous efforts with its feet to move from the place, but its captor, though of lesser bulk, had also six legs, which took such firm hold of the glass that it remained immovable, other than a slight movement of the fore part of the spider from side to side, and a slight rising upward at times, as if for the purpose of lifting the fly from its feet, or rather hold. I did not stay to see the death of the fly, which was a tedious process, and when I returned shortly both spider and fly had disappeared.

This stealthy advance, when realised, "gave one the creeps"; it was like a nightmare, especially when remembering that it was allied to so much ferocity and cunning. A comparison might be made of a man clutching a very large sheep or a calf, one hand resting on the head, the other across the rump, the hands not grasping, but the animal being securely held by the inward pressure of the arms, while the man's teeth were employed tearing open the beast's flank, and he greedily sucking the struggling creature's life's blood.

Art. LIII.—*Arachnids: the Small Pond in the Forest.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute.*]

On a certain day, towards the end of the spring of the year 1894, I was employed felling a portion of light bush—that is, in other words, clearing a piece of land overgrown with small-sized trees—and, becoming thirsty, went a short distance to where a small pond or hollow was full of nice clear water, shaded by the overhanging scrub. On kneeling down at the edge of the water I noticed a kind of dust or minute particles floating on the surface. Observing these attentively for a short time, it was seen that the supposed dust was composed of multitudes of almost microscopic creatures. These small objects were so minute that their exact form could not be perceived, but from their actions and habits I have little doubt that they were a species of Arachnid, closely allied to the spider kind. Numbers were seen at intervals clustered together, and these clusters of mites were evidently surrounding the bodies of small flies or insects which had fallen on the surface of the water. No doubt the mites were employed feasting on the bodies of drowned insects, most of which were so small as to be nearly imperceptible to the human eye. These small Arachnids could travel over the surface of the water at great speed—in fact, they lived on the surface, and did not enter the water, but travelled over the surface as easily as if the water were solid or compact ice. Single Arachnids would come from the crowd and rush away over the water and join other groups of Arachnids, and by close observation the surface of the water was seen to be teeming with these small creatures, and they were all moving and changing places continually. In a great measure they reminded me of a large assemblage of people at a skating carnival.

Below the surface of the water were other creatures which came in sight occasionally, and if my memory is not at fault I have seen these, or a closely allied species, in England. As a boy I knew them by the name of "boatmen"—not the water-beetle which is sometimes so named, but quite a different creature. These were of a yellowish-brown colour, the body perhaps ½ in. in length, and much like a bit of stick or a twig. Only two legs were perceptible, and these stood at right angles to the body, and resembled oars. These oars were placed "a little for'ard of amidships," as a sailor would

say. At intervals a "boatman" would come to the surface and then dart away in a horizontal direction. A favourite amusement was to rush furiously at another of their kind and "ram" him in the middle of the body with the head and then go off in another direction, not staying to do battle, or to give the injured one an opportunity to retaliate.

I took particular notice to see if the "boatmen" ate or otherwise interfered with the minute Arachnids; but they seemed to pay no attention to them, nor did the smaller creatures show any sign of fear or hurry in the presence of a "boatman." Not having any microscopical appliances with me, or time to make further study of these small Arachnids, I am unable to give further information on the subject, and perhaps may never see the like again.

The pool of water is still there, but a large fire has passed over the land, and, all shelter being now removed, it is not likely that these creatures would find the pool a suitable position to increase and multiply as heretofore.

I forwarded a description of the habits of these little objects to one who is well versed in these subjects, but he said that such had not come under his observation. They certainly are of a sort which are seldom seen, and, I would suppose, difficult to find. The speed with which the single Arachnids skated over the water was something marvellous; but in the clumps where they collected about an insect body close attention had to be given to make certain they were not dust particles wafted by the breeze over the surface of the pool.

NEW ZEALAND INSTITUTE

NEW ZEALAND INSTITUTE.

Thirty-first Annual Report.

The Board held meetings on the 26th January and 7th September, 1899.

Messrs. Tregear and Mason retired from the Board in compliance with the Act, and there was a third vacancy caused by the death of the late Mr. Maskell. His Excellency the Governor reinstated the two retiring members, and appointed Mr. J. W. Joynt to fill the third vacancy.

The following gentlemen were elected by the incorporated societies to be Governors of the Board for the year—viz., Mr. James McKerrow, Mr. S. Percy Smith, and the Hon. C. C. Bowen.

There are now five vacancies on the roll of honorary members, the vacancies during last year having been caused by the deaths of Sir George Grey, Sir George Bowen, and Sir Frederick McCoy.

The members now on the roll are: Honorary members, 25; Auckland Institute, 163; Hawke's Bay Philosophical Society, 61; Wellington Philosophical Society, 141; Philosophical Institute of Canterbury, 75; Otago Institute, 105; Nelson Philosophical Society, 16; Westland Institute, 59: making a total of 645.

The volumes of Transactions now on hand are: Vol. I. (second edition), 233; Vol. V., 8; Vol. VI., 15; Vol. VII., 98; Vol. IX., 98; Vol. X., 129; Vol. XI., 27; Vol. XII., 29; Vol. XIII., 30; Vol. XIV., 53; Vol. XV., 164; Vol. XVI., 164; Vol. XVII., 163; Vol. XVIII., 135; Vol. XIX., 154; Vol. XX., 155; Vol. XXI., 87; Vol. XXII., 89; Vol. XXIII., 163; Vol. XXIV., 167; Vol. XXV., 167; Vol. XXVI., 173; Vol. XXVII., 176; Vol. XXVIII., 180; Vol. XXIX., 450; Vol. XXX., 400; Vol. XXXI., not yet fully distributed.

The volume just published (XXXI.) contains seventy-two articles, and also addresses and abstracts which appear in the Proceedings. The volume consists of 802 pages and 62 plates.

The following gives a comparison of the contents of the present volume and that for last year:—

	1899. Pages.	1898. Pages.
Miscellaneous	100	138
Zoology	262	245
Botany	220	66
Geology	72	31
Chemistry	50	28
Physics		28
Proceedings	48	54
Appendix	50	48
	802	638

The cost of printing Vol. XXX. was £416 15s. 9d. for 638 pages, and that for the present volume (XXXI.) £539 6s. 3d. for 802 pages. This amount includes the preparation and printing of the plates.

The treasurer's statement of accounts hereto appended shows that the credits for the year were £1,261 2s. 9d., and the expenditure £768 13s. 3d., leaving a balance of £492 9s. 6d. This balance is already appropriated for the completion of the "Maori Art" (Parts IV. and V.) and other works, the accounts for which are not yet presented.

A consignment of Part IV. of "Maori Art" has just been received from the publisher, and Part V., which completes the work, is already in the press.

James Hector, Manager.

Approved.—Thomas Mason, Chairman.—Wellington, 7th September, 1899.

New Zealand Institute Accounts for 1898–99.

Receipts.	£	s.	d.	*Expenditure.*	£	s.	d.
Vote for 1898–99 ..	500	0	0	Printing Vol. XXXI. ..	539	6	3
Contribution from Wellington Philosophical Society	20	0	10	Expense of publishing "Maori Art" for year	199	3	9
Sale of Transactions of Institute	3	0	6	Expense of library—altering and fitting up after removal of Patent books	13	15	0
Sale of "Maori Art" ..	102	3	2	Interest charged by bank for overdraft on deposit	2	15	3
Balance of Deposit Account transferred to General Account ..	635	18	3	Miscellaneous items ..	13	13	0
				Balance in hand * ..	492	9	6
	£1,261	2	9		£1,261	2	9

* This balance is already appropriated for the completion of the "Maori Art" and other works.

Wm. Thos. Locke Travers,
7th September, 1899. Honorary Treasurer.

PROCEEDINGS

WELLINGTON PHILOSOPHICAL SOCIETY.

First Meeting: *11th July, 1899.*

Mr. E. Tregear, President, in the chair.

The President called attention to the loss the Society had sustained owing to the death of the late Mr. F. E. Clarke.

He said he had contributed most valuable papers to the Transactions on the subject of the fishes of New Zealand.

Sir James Hector also drew attention to the valuable work that Mr. Clarke had done in this particular branch of science.

Papers.—1. "On Maori Spirals and Sun-worship," by E. Tregear, F.R.G.S. (*Transactions*, p. 284.)

Sir James Hector said the paper was a valuable one, full of erudition, and with a good deal of original matter. He had questioned an old Maori carver on the subject of the bow ornaments of the war-canoe, and had been answered that they were copied from the spiral markings on the skin of the thumb. Having made some experiments, he found to his surprise that the thumbs of Europeans gave single spirals, whilst those of many Maoris (though not of all) gave double spirals. It might yet be found that this distinction gave valuable information as to the race-limits and even as to the origin of the Polynesian.

Mr. Hogben stated, in corroboration of what had been said in the paper about the peasants in the Old Country jumping through the Beltine fires in honour of Baal, the Sun-god, that he had noticed the lines of people had always moved in one direction—viz., that of the sun's course.

Mr. Tregear, in reply, said he considered if there was any difference between the thumb-markings of Maoris and Europeans that such discovery would be of great ethnic interest. As to a modern Maori's opinion on such a subject as the origin of the double spiral in carving, it was worthless as evidence. One Maori would say that it came from the unfolding fern-frond, another from the thumb-marking, &c. None of them could possibly know why their ancestors three thousand years ago used the mark, unless a legend of undoubted antiquity had been handed down from that period, and no such legend on the subject was at present known.

2. "Notes on *Notornis mantelli*," by R. Henry; communicated by Sir J. Hector. (*Transactions*, p. 53.)

3. "On Hereditary Knowledge," by R. Henry; communicated by Sir J. Hector. (*Transactions*, p. 51.)

Mr. Harding, Mr. Hudson, Mr. Tregear, and Sir J. Hector gave some interesting information on the habits of certain birds and animals, which seemed to indicate that they had something more than mere instinct.

4. "On the Result of Crossing with the Muscovy Duck and Andalusian Drake," by Coleman Phillips. (*Transactions*, p. 56.)

The author exhibited a specimen of the bird described.

The following additions to the Colonial Museum were exhibited at the meeting:—

1. Chrome-ore: newly discovered vein, 9 ft. wide, in Croixelles Harbour, Nelson.

2. *Stringops habroptilus* (the kakapo), of a pure canary-yellow colour.

In the Museum there is a specimen of the kaharike (*Platycercus*, sp.), with exactly the same colouration.

3. Feather-mat made by Maori women; presented by Mr. E. Best.

4. Ferret (*Mustella furo*); mounted by Mr. Yuill.

5. Two small kind of guinea-pigs; mounted by Mr. Yuill.

6. Drake, result of cross; presented by Mr. C. Phillips.

7. Tamil bell, formerly belonging to the late Rev. W. Colenso.

8. *Holothuria radis.*

9. *Squilla armata;* presented by Mr. Hebberley.

10. Flax; presented by Mr. Potter.

11. Cassowary; presented by Dr. De Vis, of Queensland.

12. Homing pigeons.

13. Photograph of the tuatara; presented by Mr. F. J. Denton.

The President read a letter from Mrs. M. Thomas in which she presents, on behalf of the subscribers, the portrait of the late Mr. C. Hulke.

The picture was accepted with thanks, and placed in the Museum.

Second Meeting: *8th August, 1899.*

Mr. E. Tregear, President, in the chair.

New Members.—Mr. E. W. Newman and Dr. J. Smith Purdy.

The President laid on the table a copy of Mr. G. V. Hudson's new work on "New Zealand Moths and Butterflies."

He congratulated Mr. Hudson on his having produced a valuable addition to the scientific literature of New Zealand.

Sir James Hector also considered the work most valuable.

Papers.—1. "On the Tohunga-Maori: a Sketch," by S. Percy Smith, F.R.G.S. (*Transactions*, p. 253.)

Sir James Hector said this was a valuable paper, and threw a flood of light on a subject little was known about. It was interesting to know that we had a member capable of gathering information regarding the earliest type of mankind. They must have been descended from a race that acquired a written language, as was evident from their carvings and their pottery.

Mr. Harding considered the acts of the people described by the author were not the property of any particular priesthood; they occurred in other countries down to the present day. The acts of the priests in Egypt were just like those of the Maori *tohunga.*

Mr. Phillips said the writings on the pottery were quite sufficient to prove that the Polynesians had a written language.

Mr. Tregear had listened with great pleasure to Mr. Smith's paper. It contained most valuable information about these old priests and their customs. The story of the fire-walking, he thought, could hardly be explained. He hoped they would hear other papers from the author.

2. "On Tuberculosis in Pheasants in Wanganui," by S. H. Drew, F.L.S. (*Transactions*, p. 54.)

Sir James Hector gave a description of the bird *Phasianus reevesii* and its habits.

Several specimens, additions to the Museum, were shown by Sir James Hector, among others a fine example of the frost-fish (*Lepidopus caudatus*), presented by Mr. Petrick; and *Pimelepterus drewii*, presented by Mr. Hurcombe.

Third Meeting: *12th September, 1899.*

Mr. E. Tregear, President, in the chair.

New Members.—Mr. George Hogben, Professor R. C. Maclaurin, M.A., Mr. J. W. Joynt, M.A.

Copy of Vol. XXXI. of the "Transactions of the New Zealand Institute" and Part IV. of "Maori Art" were laid on the table.

Papers.—1. "On *Macro-lepidoptera*," by G. V. Hudson, F.E.S. (*Transactions*, p. 10.)

The President said this was a valuable addition to the information already collected on this subject by the author, and contained in his recently published work on the moths and butterflies of New Zealand.

2. "On Maori Skeletons and Relics found at Karaka Bay," by H. N. McLeod. (*Transactions*, p. 271.)

Sir James Hector said he did not think the crushed shells mentioned were decomposed, but merely the ordinary shells that grew on the rocks on the shore-line. This locality was a celebrated spot for finding remains of this kind. The late Mr. J. C. Crawford had written an interesting account of the whole peninsula, and made large collections of Maori remains. He (Sir James) described the kind of stone the weapons were made of, and where it was found.

Mr. Richardson said about five years ago some articles appeared in the *New Zealand Times* on this subject, he thought written by Mr. E. Best.

Mr. Harding said there were interesting articles on this subject in *Chapman's Magazine* about 1860, and also by the late Major Heaphy on the greenstone country, which would be worth reprinting.

The President said it would be a good thing if all such information could be collected and published in the *Transactions.*

Mr. Hustwick said he met a man in the Taupo district named Pruin who had a splendid collection of Maori relics; it would be worth while getting a description of them.

3. "On Pliocene Fossil Shells from Wanganui," by R. Murdoch. (*Transactions*, p. 216.)

Sir James Hector said this was a carefully prepared paper, and the drawings were very good. He thought, however, some of the specimens had already been described.

Sir James Hector gave a description of the new earthquake-recorder, which he had set up temporarily in the hall.

He also gave a general description of earthquakes and their supposed origin.

Mr. Hogben added some very interesting information regarding this instrument, which had been brought to such perfection by Mr. John Milne. He thought we were to be congratulated on having such an instrument in the colony. We should not, however, forget that it was Dr. E. von Rebeur-Paschwitz who first invented the horizontal pendulum for the recording of earth-shocks.

The President said we had to thank Sir James Hector and Mr. Hogben for the interesting and instructive explanation they had given of the working of the seismometer.

Sir James Hector exhibited specimens of fish, ducks, and sponges.

FOURTH MEETING: *12th December, 1899.*

Mr. E. Tregear, President, in the chair.

Paper.—"On the Volcanoes of the Pacific: No. II.," by Coleman Phillips. (*Transactions*, p. 188.)

Sir James Hector adversely criticized the theories advanced by Mr. Phillips, who, he said, seemed to mix up geological time and human time. He pointed out that the bursting-up of a volcanic island was no proof of general upheaval. Indeed, on the contrary, to most geologists it was proof of subsidence. He further pointed out that volcanic islands were built up, not thrust up. There were a great number of atolls in the Pacific that clearly and distinctly proved, as Darwin had pointed out, that there had been a continuous subsidence of the land on which the coral had its foundation. There were other places where the coral had risen. True, the volcanic islands were formed by accretions till they rose to such an extent that coral could grow on them; but such islands were only pustules, rising from the bottom of the sea, and they were very insignificant in comparison with the large area in which they were evolved. What they wanted in this matter was not theorising, but the

close collection, accurate analysis, and statement of facts. The recent coral-boring experiments at Funi-futi gave conclusive evidence of subsidence. The bore had been down 1,300 ft., and was not out of the dead coral yet. As coral did not live below a small depth, this was a sign that the bottom of the sea there had been gradually going down.

The President said, although the paper was very interesting, he did not think the author had brought forward sufficient evidence to prove his views regarding the volcanoes of the Pacific and his upheaval theory.

Mr. Phillips, in replying, said he had collected as many facts as he could. He had not had time to read the whole of his paper, but when it was published it would be found that it did contain facts and figures. In geological matters he would not, however, for one moment pit himself against Sir James Hector.

The following additions to the Museum were exhibited and remarks made on them by Sir James Hector:—

1. Spider-crabs.

Sir James Hector said there had been for some time past, in the Museum, a few claws of a very large crab collected by him in Perseverance Harbour, Campbell Island, and there had been some speculation as to what species they belonged to. Recently, in going through the spirit-room of the Museum, an old jar—one of those given to the late Captain Fairchild on his cruises round the coast—was unearthed, and on examination it was found to contain a new species of crab. The old label on the jar was almost worn away, but sufficient remained to show that the specimens it contained came from Campbell Island. On examination these were found to be large specimens of spider-crabs—far exceeding in size any ever discovered in New Zealand or anywhere else. They were of the genus *Paramicippa*, there being one male and a number of females. He said he had searched in the voyage of the "Venus"—the only exploring ship that had ever gone to Campbell Island—and he could find no account of any spider-crab belonging to the genus *Paramicippa* at all approaching these in size. There was one species belonging to New Zealand, but from head to tail it was only a little over ½ in. in length, and it differed very much from the Campbell Island specimen. A feature of the specimens was the peculiar pointed turned-down nose, which gave the crab a remarkable toad-like aspect. The claws in the Museum belonged to still more gigantic specimens of the same genus, which, if discovered, would prove a valuable marketable commodity, and, if found on the adjacent islands, would be well worth transferring to our coastal waters. He had named the new species *Paramicippa grandis*, and, as he had only one male and ten female specimens, he would be willing to exchange some of the latter with other museums. Perseverance Harbour, where, no doubt, these crabs were found, was a most interesting locality, containing the coal formation of New Zealand and other geological features, as well as large quantities of fossil wood.

2. New Zealand crow.

Sir James Hector, in drawing attention to this very fine specimen of the New Zealand crow, or jay, as it should more properly be called, made interesting reference to the complete isolation of the orange-wattle crow in the South Island and the blue-wattle crow in the North Island. It was strange, he said, that a narrow strip of water like Cook Strait should make the line of demarcation in the species so distinct. The manner in which the two species were so absolutely circumscribed held good in an extraordinary way. For instance, he showed that an albino of the blue-wattle species kept the blue wattles, while an albino of the South Island species still kept the yellow wattles. Thus we were face to face with one of the most curious problems in the colouration of birds.

Apparently a bird would "sport" in the colour of its feathers, though in anything in the nature of skin it would not do so.

3. Cuttle-fish (*Architeuthis verrilla*).

Portions of a huge cuttle-fish were found at Island Bay about ten years ago, and described by Mr. T. W. Kirk in the "Transactions of the New Zealand Institute," vol. xiv., p. 284. These remains have been in possession of the Museum authorities for some time, and have now been skilfully arranged for public exhibition by Mr. A. Yuill. The two long tentacular arms, which have apparently not been preserved, were each 30 ft. in length when extended, so that the fish had a reach of no less than 20 yards. Bathers at Island Bay would do well to keep their weather eye open for such ugly denizens of the deep.

4. Recently discovered New South Wales opals—a very handsome collection; presented by Mr. W. M. Hunt, of Masterton.

5. Young specimen of a rare fish (*Centriscus humerosus*); presented by Mr. Travers.

6. Puriri block, with Maori stone adze embedded in it; presented by Mr. Lister, of Kohukohu.

7. The shining cuckoo.

Sir James Hector said the cuckoo had made a somewhat early visit to New Zealand this year, and a beautiful specimen of the little shining cuckoo had just been added to the collection in the Museum. This bird came down here every spring, generally in the month of September, from the Andaman Islands, south of Burmah, and even from the Phillipine Islands. It was a delicate little bird, with beautiful plumage. The specimen secured by him must have been hatched here last year, for these birds nested in New Zealand. It then went home to some tropical country, spent the winter there, and returned on another trip to New Zealand. The instinct that carried these birds to and fro between such far-distant countries as New Zealand and the Phillipines was truly wonderful. It might be, however, that the bird had a nearer winter home in some of the South Pacific islands, such as Tonga or Samoa. A bigger cuckoo, however, visited New Zealand from Tahiti, and a curious point about it was that it selected the only pensile nest there was in New Zealand—namely, that of the fantail—for the purpose of hatching its eggs. These pensile nests were more common in tropical countries where the cuckoo came from. These birds turned the eggs of the fantail out of the nest to lay their own there, and the little fantails had to hatch out these bigger eggs for the interloper. This, he added, went on year after year.

8. Fossil bones (Cetacean), from Hangaroa River, near the Gisborne–Rotorua stock-track; found by Mr. J. B. Jackson, and presented to the Museum by Mr. S. Percy Smith.

ANNUAL MEETING: *20th March, 1900.*

Mr. E. Tregear, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

During the past year the Society has held five general meetings, at which thirty-six papers and communications were read.

Five new names have been added to the roll of members.

The balance-sheet shows that the receipts for the year, including the balance carried forward, amount to £172 11s. 8d., and the expenditure to £77 0s. 2d., leaving a balance in hand in current account of £95 11s. 6d.

There is also the Research Fund at fixed deposit, now amounting to £34 9s. 6d., which increases the credit balance to £130 1s.

ELECTION OF OFFICERS FOR 1900.—*President*—G. V. Hudson, F.E.S.; *Vice-presidents*—Sir James Hector, H. B. Kirk, M.A.; *Council*—George Denton, Martin Chapman, G. Hogben, M.A., R. C. Harding, H. N. McLeod, R. L. Mestayer, E. Tregear, F.R.G.S.; *Secretary and Treasurer*—R. B. Gore; *Auditor*—T. King.

Papers.—1. "The Polynesian Name for Spider," by E. Tregear, F.R.G.S. (*Transactions*, p. 298).

2. "Explorations in the Te Anau District," by A. C. Gifford.

The journey was made by himself and three other gentlemen in January of this year, from the north fiord of Lake Te Anau to Bligh Sound and back. He claimed that this was the first time the journey had been completed by Europeans. In illustration of his narrative Mr. Gifford exhibited collections of very excellent photographs which he secured *en route*. Numerous points of interest in connection with the journey were dwelt upon by the speaker. At one stage, he said, the streams were found to be of a chocolate colour, due to some growth in their beds. The Kareni Falls were remarkable for the exceedingly narrow space into which the river was compressed in making its plunge. Another fall to the westward was described as being notable for its extreme beauty. The lowest level of the summit of the pass was 3,700 ft. On its westward side the travelling was much easier than on the Lake Te Anau side. A creek in one valley was remarkable for the large number of pot-holes which it contained. They were of all sizes. Some were as much as 10 ft. across and 8 ft. deep, while all had the stones in them which had made them. A long and narrow cañon and a river which disappeared underground were among other wonders encountered. For a quarter of a mile from the place where the river was lost to sight it could be heard roaring underfoot, but afterwards the sound diminished, and was ultimately lost. At one point the party saw thousands upon thousands of caterpillars climbing from the ground to the branches of shrubs by means of lines of their own making. The kea parrots threatened the travellers as they made their way through the mountainous country. Numbers of blue-duck were seen, and many penguins in Bligh Sound. Only two rabbits were noticed, one on the very summit of the pass and the other on the shore of the sound. The mountain flowers were profuse and very beautiful. There was much less snow about than usual. A great deal of rain fell, and on the return journey the weather was particularly bad. It was found that the food and effects which had to be carried could not

be kept at less than 1 cwt. per man, and in consequence every part of the track taken had to be covered three times.

Mr. Harding suggested that if Mr. Gifford's paper was published he should illustrate it by means of some of the very beautiful photographs which he had taken.

Sir James Hector thanked the author for his address, which had been prepared at his special request, on very short notice. The toils, dangers, and hardships of such an exploration were most graphically described, and were easily recognised by early explorers, though known to but few modern tourists. The beautiful but appalling character of the scenery of this wonderful district of New Zealand was also excellently illustrated by the author's photographs, taken under great difficulties. The same country had been partially explored in 1863 by himself (Sir J. Hector), but he had chiefly followed the mountain-tops and avoided the valleys. At the time of the first visit of the Admiralty survey-ship "Acheron" in 1850 there was a considerable Maori camp at the head of Bligh Sound. The natives were not seen, but their fires were found, and several mats and other articles obtained. In 1863 he himself followed up this flat valley on an old trail for some distance, the Maoris he had with him telling him that it led through to the Te Anau Lake and to Milford Sound, but most probably the trail, which was soon lost, led over the mountains, and did not follow the rugged valley and pass which the author and his party had discovered.*

Mr. Hudson said the caterpillars seen by Mr. Gifford would be geometers. They had probably been frightened by a strong wind, and let themselves down from the shrubs, and were ascending again when the travellers saw them.

Mr. Tregear said there was no occasion for Mr. Gifford to apologize that his narrative was not scientific. It was the duty of the Society to encourage exploration, and he was sure that Mr. Gifford's account of his party's journey was highly interesting.

3. Notes by Sir James Hector on a collection of Virginian quail (*Coturnix*) recently imported by the Acclimatisation Society.

Sir James Hector said the specimens were some of those that died on the passage, and were most artistically mounted by Mr. Yuill, taxidermist to the Museum. He reminded members that quails had a world-wide distribution. The common quail of Europe was migratory, and flew by night, and was shot and snared in thousands in southern Europe for the supply of the market in large cities. During the migrations the males arrived first, and, as they did not pair like the closely allied partridge, but were polygamous, they indulged in furious contests for supremacy, and thus fell a ready prey to the fowler. New Zealand had a native quail (*Coturnix novæ-zealandiæ*), which was a very fine bird, and abounded, in the early days of settlement, in the open grass lands of Nelson, Canterbury, and Otago, and afforded excellent sport, as many as two or three dozen pairs being considered a fair morning's bag. Now they were quite extinct, as, being ground-birds, they fell an easy prey to the many enemies introduced into the colony. The brown quail of Australia was a closely allied species, but was a smaller bird. A few had been turned out in the North of Auckland and up the Wanganui Valley, but they had not thriven, no doubt for the same reasons which had led to

* Owing to the rapids and scattered fragments of rocks it was not possible to examine the river beyond two miles from its mouth, when the "Acheron" party came on the fresh footmarks of some natives, who were heard making their escape through the thick underwood. These people, as far as we could learn, belong to a small, isolated, and almost unknown tribe.—Notes by Captain Stokes, H.M.S. "Acheron," published in the "New Zealand Pilot."

the destruction of the native species. The Californian or plumed quail was introduced more than twenty years ago, and had spread all over the islands with great vigour, and in many parts become quite abundant. It had the advantage of being to some extent a roosting bird, and thus escaped a certain class of enemies, but it seemed to be gradually succumbing to the continued attacks of fowlers with nets, who caught them in large numbers for the market and for the supply of canneries; and it was rare now to see the large flocks of this Californian quail which used to be common in many parts of the country. The Virginian quail (*Perdix (Ortyx) virginiana*) was often termed the "American partridge," or the "bob-white," which represented its clear call-note. Its flesh was excellent in autumn, as it fed on grain, and took a lot of it. It sheltered in the low trees and brushwood round the open fields, and in winter became very bold, approaching human habitations in search of food, and boldly fighting with poultry for a share of their grain. At this season as many as ten or fifteen were frequently caught at one time under a drop-coop trap. This bird was the largest of the quails, and laid fifteen to twenty-four pure-white eggs under the shelter of a grass-tuft. The chicks ran about as soon as they were out of the shells, and the little ones were led off by their mothers to the best feeding-places. These quail roosted on the top of a knoll in the middle of open ground, sitting in a close circle with their heads directed outwards and their tails touching, so that they were on the alert against attack.

Mr. Tregear exhibited a cone-shaped frame of cane covered with cobwebs.

He said the exhibit was from Tanna, New Hebrides, where similar cones were used as head-gear by dancers. In Samoa these frames were put in dark places, where they were spun over by poisonous spiders. They were then used as a means of inflicting a cruel punishment, which consisted in placing the cones on the heads of offending natives, who suffered terribly from the bites of the insects.

Mr. Hustwick said a similar thing was used in Madagascar, only it was an enclosure with the spiders in the roof.

The following exhibits were shown, and explained by Sir James Hector:—

1. A karaka log with Moriori workings showing ownership, obtained at Chatham Islands.

Mr. Travers pointed out that these marked logs were used for fixing boundaries. He had mentioned this in a paper he had read some years ago.

2. Specimen of the group Centipedes (*Julidæ*), collected by Mr. F. J. Robertshaw, of Picton, from a bunch of bananas.

This was the third specimen obtained, and had been distinguished as *Spirosterptes fijiensis*. They were quite harmless, except on account of the strong and unpleasant odour which they give off.

3. Two specimens of crayfish—*Paranephrops setosus*, from Urenui Creek, Taranaki district, collected by Mr. Halcombe; and *Paranephrops horridus*, from Foxton, obtained by Mr. W. T. L. Travers (a gigantic specimen: length, including outstretched arms, 11 in.; carapice, 3 in.; abdomen, 4 in.; anterior legs, 5·5 in.; greatest width of carapice, 1·5 in.: probably a new species, but agrees with the species quoted in many respects).

4. Relics of the first New Zealand Printing Press, by R. Coupland Harding. (*Transactions*, p. 400.)

Mr. Harding said the late Rev. W. Colenso, of Hawke's Bay, had bequeathed to him a quantity of printing material. In going through the material he found two large "cases," which still had type in them. These cases were the original ones which Mr. Colenso used when he first came to New Zealand. They were made in 1836, but were in excellent preservation. It was his (Mr. Harding's) wish, if the authorities were agreeable, to present the cases and sundry other relics of the first printing-office in New Zealand to the Colonial Museum.

Sir James Hector said that Mr. Harding's gift would be accepted for the Museum with great pleasure.

AUCKLAND INSTITUTE.

First Meeting: *12th June, 1899.*

Mr. J. Batger, President, in the chair.

New Members.—W. Bonar, J. Chambers, Dr. Macarthur, E. V. Miller.

The President delivered the anniversary address, taking as his subject "Capital and Modern Progress."

Second Meeting: *26th June, 1899.*

Mr. J. Batger, President, in the chair.

Professor F. D. Brown delivered a popular lecture on "The Electric Spark," illustrated with experiments.

Third Meeting: *17th July, 1899.*

Mr. J. Batger, President, in the chair.

Dr. R. H. Makgill gave a lecture on "Water-supply and Disease-germs."

Fourth Meeting: *14th August, 1899.*

Mr. P. Marshall, F.G.S., delivered a popular lecture, illustrated with lime-light transparencies, on "Ruapehu and its Neighbourhood."

The lecturer described the geology, botany, and physical features of the mountain and surrounding table-land, and gave much interesting information as to the best route to be taken in ascending the mountain.

FIFTH MEETING: *28th August, 1899.*

Mr. J. Batger, President, in the chair.

New Member.—Rev. J. T. Pinfold.

Papers.—1. "On the Geology of Castle Rock, Coromandel," by J. M. Maclaren. (*Transactions*, p. 213.)

2. "The Coming Star Showers," by Professor H. W. Segar.

SIXTH MEETING: *11th September, 1899.*

Mr. J. Batger, President, in the chair.

Professor C. W. Egerton gave a popular lecture on "The Novel."

He fully described the evolution of the modern novel, particularly during the Victorian period, and showed how the predominant taste for novel-reading affected other forms of literature, and entered upon some speculations as to the probable development of the novel in the future.

SEVENTH MEETING: *25th September, 1899.*

Mr. J. Batger, President, in the chair.

Papers.—1. "On the Percentage of Chlorine in the Waters of Lake Takapuna," by J. A. Pond, F.C.S. (*Transactions*, p. 241.)

2. "Some Experiments in Radiant Heat," by E. V. Miller.

EIGHTH MEETING: *23rd October, 1899.*

Mr. J. Batger, President, in the chair.

Mr. T. F. Cheeseman, F.L.S., gave a popular lecture on "Rarotonga: its Scenery, Vegetation, and Native Inhabitants."

The lecture was illustrated with a series of over eighty lime-light transparencies.

NINTH MEETING: *6th November, 1899.*

Mr. J. Batger, President, in the chair.

New Member.—F. J. Povey.

Papers.—1. "On the Composition of the Soil of the

Taupo Plains, and its Suitability for the Growth of Grasses," by J. A. Pond, F.C.S., and J. S. Maclaurin, D.Sc. (*Transactions*, p. 227.)

2. "Maori Origins," by Elsdon Best. (*Transactions*, p. 294.)

Annual Meeting: *19th February, 1900.*

Professor Talbot-Tubbs, Vice-president, in the chair.

Abstract of Annual Report.

Five new members have been elected during the year, the total number of members at the present time being 153.

The Council regret to announce the death of Lieut.-Colonel T. L. Murray, who has been connected with the Institute for more than twenty years, and who during the whole of that period has taken a steady and consistent interest in its affairs. For the last two years he has served as a member of the Council.

The total revenue of the working account, excluding the balance of £84 4s. 9d. brought from the previous year, has been £900 18s. 2d. Last year the amount was £899 2s. 10d., very nearly the same sum. Examining the separate items of the balance-sheet, it will be seen that the receipts from the invested funds of the Costley bequest have been £328 5s., against £365 16s. 3d. for 1898–99, the reduction being mainly due to a temporary delay in the payment of interest on one of the investments. The Museum endowment has yielded £444 1s. 4d., the amount for the previous year being £355; while the sum received for members' subscriptions stands at £118 13s., showing a reduction of £9 9s. The total expenditure has been £923 16s. 10d., leaving a balance of £61 6s. 1d. The Council have no change to report respecting the invested funds of the Institute, the amount being the same as last year—£13,590.

At the close of the year Mr. Percy Smith resigned his position as one of the trustees of the Institute, after holding it for fifteen years. The Council are anxious to put on record their appreciation of Mr. Smith's long-continued services, and of the careful attention that he has always given to the affairs of the Institute. It is pleasing to know that his name still remains on the roll of the Institute, and, though no longer serving it in an official capacity, he still has the intention of assisting in its work whenever opportunity occurs.

Nine meetings have been held during the year, at which twelve papers were read.

The register of the Museum shows that 13,230 people entered the building on Sundays, the total for the whole year being 49,082.

The chief progress made by the Museum has been in the ethnographical department. Mr. Elsdon Best, of Ruatahuna, has forwarded a second collection made by him among the Maoris living near Lake Waikaremoana, which contains several articles not previously represented in the Museum. A beautiful *toki-hohoupu*, or battle-axe, with elaborately carved wooden handle of great age and perfect preservation, has been obtained by purchase, together with several rare bone and greenstone ornaments. During a visit to Rarotonga the Curator collected a series of 132 articles illustrating the ethnology of that island; and through the kind offices of the Rev. Mr. Cullen, seconded by Colonel Gudgeon, two of the celebrated carved ceremonial axes from Mangaia have been secured.

An interesting exchange has been received from the Bishop Museum at Honolulu, in the shape of two of the rare kahilis, or wands, elaborately decorated with feather-work. Through the kind co-operation of Mr. W. S. Laurie, of this city, a very acceptable collection of mound-builders' pottery from the Mississippi Valley has been obtained from Dr. Bushnell, of St. Louis. There have also been some minor additions, which it is impossible to mention here. In the zoological department the most noteworthy accession has been an almost perfect moa skeleton, purchased from Mr. Kingsley, of Nelson. It has a special value from being the type of Captain Hutton's new species, *Dinornis torosus*. Two remarkably good mounted specimens of *Echidna* and *Ornithorhynchus* have been presented by Mrs. Calder, of this city; and several rare New Zealand bird skins have been purchased. The want of a resident taxidermist is severely felt. Among the miscellaneous additions special mention is made of a valuable timber exhibit presented by the Leyland O'Brien Timber Company. It consists of a complete section of a kauri-tree 6 ft. in diameter, supporting a framework containing panels of the chief ornamental woods of the colony. It affords an excellent illustration of the value of our timber trees for furniture or decorative woodwork.

The most noteworthy addition to the library has been a complete set of the publications of the United States Bureau of Ethnology, in sixteen volumes quarto.

The management of Little Barrier Island as a reserve for the preservation of the avifauna of New Zealand still remains in the hands of the Institute, the Government contributing an annual grant of £200 to cover the expenses in connection with it. The Curator, Mr. Shakespear, reports that matters are in a satisfactory condition on the island, and that most of the native birds appear to be increasing in numbers now that they are not in any way molested. A short time ago he detected two men at work on the island gum-digging. He at once turned them off, and reported the occurrence. It is the intention of the Crown Lands Department to proceed against the men as soon as they can be found. With this exception, no attempt has been made to land upon the island, or to interfere with it in any way.

Election of Officers for 1900.—*President*—Professor H. W. Segar; *Vice-presidents*—J. Batger, Professor H. A. Talbot-Tubbs; *Council*—Professor F. D. Brown, C. Cooper, F. G. Ewington, E. A. Mackechnie, P. Marshall, F.G.S., T. Peacock, D. Petrie, F.L.S., J. A. Pond, F.C.S., J. Stewart, C.E., Professor A. P. Thomas, F.L.S., J. H. Upton; *Trustees*—E. A. Mackechnie, T. Peacock, J. H. Upton; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.; *Auditor*—W. Gorrie.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

First Meeting: *3rd May, 1899.*

Mr. L. Cockayne, President, in the chair.

Address.—Professor Arnold Wall delivered an address on "The Life-history of Words."

Captain Hutton exhibited and described a trephined Maori skull (Plate XXV.), and a Maori albatros-hook, lately acquired by the Canterbury Museum.

Second Meeting: *7th June, 1899.*

Mr. L. Cockayne, President, in the chair.

New Member.—Mr. W. D. Andrews.

Address.—Mr. J. S. S. Cooper delivered an address on Wireless Telegraphy," illustrated by experiments.

Third Meeting: *2nd August, 1899.*

Mr. L. Cockayne, President, in the chair.

New Member.—Mr. R. H. Rhodes.

Papers.—1. "The Anatomy of *Haastia pulvinaris*," by Miss E. Low; communicated by Professor Dendy. (*Transactions*, p. 150.)

2. "The Plant Geography of the Waimakariri River System: Part I.," by Mr. L. Cockayne. (*Transactions*, p. 95.)

3. "New Zealand *Musci*: the Genus *Bartramia*," by Mr. R. Brown. (*Transactions*, p. 137.)

4. "Notes on some New Zealand *Orthoptera*," by Captain Hutton. (*Transactions*, p. 19.)

5. "Note on *Paryphanta lignaria*," by Captain Hutton. (*Transactions*, p. 22.)

Mr. Robert Nairn exhibited flowering specimens of *Garrya elliptica*.

Professor Dendy exhibited specimens of the vegetable caterpillar (*Cordyceps robertsii*).

FOURTH MEETING: *6th September, 1899.*

Mr. L. Cockayne, President, in the chair.

New Members.—Messrs. H. N. Nalder and C. Harling.

On the motion of Captain Hutton, seconded by Sir John Hall, the following resolution was passed by the members standing: "The members of the Philosophical Institute of Canterbury hereby express their sorrow at the death of Mr. R. W. Fereday, who was one of the original members, served for many years on the Council, and contributed several papers to the Transactions."

Address.—Mr. T. W. Adams delivered an address on "The Damage caused to the Different Species of Forest Trees by the Long Drought of 1897–98," which was followed by an interesting discussion.

Papers.—1. "The Animal Mind as a Factor in Organic Evolution," by Mr. C. W. Purnell. (*Transactions*, p. 243.)

2. "Description of a New Species of *Halictus*," by Mr. Peter Cameron; communicated by Captain Hutton. (*Transactions*, p. 17.)

3. "On New Australian and New Zealand Lichens," by Dr. James Stirton; communicated by Mr. T. W. Naylor Beckett. (*Transactions*, p. 70.)

Mr. T. W. Adams exhibited a large collection of cones.

FIFTH MEETING: *4th October, 1899.*

Mr. L. Cockayne, President, in the chair.

Address.—Mr. J. L. Scott delivered an address on "Some Recent Developments in Mechanical Engineering."

Papers.—1. "Note on the Fresh-water Crayfishes of New Zealand," by Dr. Charles Chilton. (*Transactions*, p. 13.)

2. "On a New Genus of Mosses," by Mr. R. Brown. (*Transactions*, p. 148.)

3. "Revised List of New Zealand Seaweeds: Part I.," by Mr. R. M. Laing. (*Transactions*, p. 57.)

SIXTH MEETING: *1st November, 1899.*

Mr. L. Cockayne, President, in the chair.

Papers.—1. On the *Tipulidæ* of New Zealand," by Captain Hutton. (*Transactions*, p. 22.)

2. "On the Seedling Forms of New Zealand Phanerogams: Part III.," by Mr. L. Cockayne. (*Transactions*, p. 83.)

Dr. Evans exhibited a new form of ether saturator.

Professor Dendy exhibited some centipedes from the North Island, and a specimen of *Clematis* apparently attacked by a fungus.

ANNUAL MEETING: *4th April, 1900.*

Mr. L. Cockayne, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

Since the last annual meeting six ordinary meetings have been held, at which thirteen technical papers have been read, classifiable as follows: Botany, 7; zoology, 6.

At four of these meetings addresses of a more or less popular character have also been delivered, as follows: "On the Life-history of Words," by Professor Arnold Wall; "On Wireless Telegraphy," by Mr. J. S. S. Cooper; "On the Damage caused to the Different Species of Forest Trees by the Long Drought of 1897–98," by Mr. T. W. Adams; "On some Recent Developments in Mechanical Engineering," by Mr. J. L. Scott.

The attendance at the ordinary meetings has averaged 23·3.

The principal event of the year was the delivery of a popular lecture by Professor Benham, D.Sc., of the Otago University, on "Light Production in Animals." This lecture was delivered on the 21st July in the hall of the Canterbury College, and was very well attended by members and their friends, and very highly appreciated. It is hoped that the practice of inviting distinguished lecturers from other parts of New Zealand to deliver popular lectures on behalf of the Institute may be continued with like success this session.

The Council record with deep regret the death of one of the oldest members, Mr. R. W. Fereday.

The Council has met nine times since the last annual meeting.

The Hon. C. C. Bowen has again been nominated to represent this Institute on the Board of Governors of the New Zealand Institute.

The number of members for the year 1899 was seventy, as compared with seventy-five for the previous year.

The balance-sheet shows that the total receipts for the year have been £67 15s. 6d., including a life-subscription of £10 10s.; and the total expenditure has been £81 0s. 5d., reducing the balance in the bank to £4 15s. The sum of £10 10s., however, has been added to the invested funds.

The sum of £35 12s. 10d. has been expended upon books and binding, and the library is now in excellent order.

Election of Officers for 1900.—*President*—Captain F. W. Hutton; *Vice-presidents*—L. Cockayne, J. B. Mayne; *Hon. Secretary*—Professor A. Dendy; *Hon. Treasurer*—Captain F. W. Hutton; *Council*—Dr. Symes, H. R. Webb, R. M. Laing, Professor Wall, Professor Scott, J. S. S. Cooper; *Hon. Auditor*—George Way.

Presidential Address.—The retiring President, Mr. L. Cockayne, delivered an address on "Some Little-known Country in the Waimakariri District."

Mr. R. Nairn exhibited a flowering specimen of *Anigozanthus* from the Swan River, Australia.

Professor Dendy exhibited an experiment to show the formation of starch by green plants in the presence of sunlight.

Professor Dendy exhibited living and preserved specimens of a new species of *Peripatus* (*P. viridimaculatus*), lately discovered by him in the neighbourhood of Lake Te Anau.

This species was distinguished by the presence of only fourteen pairs of walking-legs, two rows of green spots on the back, and a prominent ovipositor in the female. It doubtless laid eggs, like the Victorian *P. oviparus*.

Other species of *Peripatus* were exhibited in comparison with the above.

OTAGO INSTITUTE.

FIRST MEETING: *12th May, 1899.*

The session was opened with a conversazione, held at the University Museum.

The President, Mr. F. R. Chapman, exhibited typical specimens from his collection of stone implements from New Zealand and other countries, as well as a series of old and rare books.

Dr. Hocken lent a number of his steel-plate engravings representing various celebrities connected with the history of New Zealand.

Mr. Hamilton exhibited a series of fine Maori mats, belts, and other articles made of flax and feathers.

Professor Benham exhibited the specimen of *Notornis** recently acquired by the Government, and deposited in the Museum; a complete moa's egg, recently obtained from the Molyneux; and a number of new and rare zoological specimens obtained during a recent trawling expedition off the coast.

Dr. De Lautour exhibited apparatus illustrating the application of Röntgen rays.

SECOND MEETING: *6th June, 1899.*

Dr. T. M. Hocken, Vice-president, in the chair.

New Members.—Dr. De Lautour, Mr. Walter Carew, Mr. C. W. Chamberlain.

Professor Benham gave an address on "The Ultimate Vital Unit," illustrated by a number of diagrams of the minute structure of the animal and vegetable cell and nucleus.

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* See Trans. N.Z. Inst., vol. xxxi., p. 743.

Third Meeting: *11th July, 1899.*

Mr. F. R. Chapman, President, in the chair.

In his opening remarks the President referred to the death of Mr. A. E. Purdie, one of the original members of the Institute.

The President then gave an account of the discovery and acquirement of a complete moa's egg, recently secured by the Museum through the good offices of Mr. Alexander Black.

The egg was exhibited at the meeting.

Professor Benham then gave a brief account of the zoological results of the trial trawling expeditions recently undertaken in the s.s. "Plucky" off the coast of Otago. (*Transactions*, p. 1.)

He exhibited and made some remarks upon several of the more interesting new animals obtained.

Mr. Hamilton exhibited Part III. of the Edge-Partington album of sketches of Polynesian ethnology, and drew attention to the large number of New Zealand objects therein figured.

Mr. Crosby Smith exhibited, on behalf of Mr. A. Black, an example of hypertrophied incisor teeth in a rabbit.

Professor Benham laid on the table a paper on the anatomy and egg of a stick insect.

Fourth Meeting: *16th August, 1899.*

Mr. F. R. Chapman, President, in the chair.

The President drew attention to the splendid work on New Zealand moths and butterflies by Mr. G. V. Hudson.

Miss Marchant read a paper on "Jane Austen."

Fifth Meeting: *12th September, 1899.*

Mr. F. R. Chapman, President, in the chair.

The Hon. Secretary, Mr. A. Hamilton, laid on the table that portion of the late Mr. T. Kirk's "New Zealand Flora" just issued by the Government.

Mr. Carew gave an account of witchcraft as practised in Fiji.

The President made some remarks on Te Puohu's raid through Otago, and suggested that the route of the invaders was by the Mataura Valley, and not by the Clutha or Molyneux Rivers.

Professor Benham read a note on *Cordyceps sinclairii* (*Transactions*, p. 4), a fungus that infests and destroys the larvæ of *Cicada*.

Specimens were exhibited.

From microscopic examination it appears that this form of *Cordyceps* reproduce only by conidia, as no asci are to be found in any of the specimens examined.

The Professor also announced the occurrence of a new species of *Balanoglossus* off our shores. (*Transactions*, p. 9.)

The specimens were obtained at Port Chalmers. The genus had not hitherto been recorded from the Southern Hemisphere.

Mr. Hamilton read a paper on a curious form of pendant ornament found in New Zealand.

He exhibited specimens, which generally had the form of a much-conventionalised fish-hook.

Mr. Hamilton also gave an outline of a paper dealing with the various forms of fish-hooks, &c., used by Maoris.

Mr. Crosby Smith contributed notes on new species of marine algæ found on the valves of *Mytilus*, and exhibited microscopic preparations thereof.

Sixth Meeting: *10th October, 1899.*

Mr. F. R. Chapman, President, in the chair.

Captain F. W. Hutton, F.R.S., delivered a lecture on "The Geological History of New Zealand." (*Transactions*, p. 159.)

In his introductory remarks Captain Hutton said no systematic geological survey had as yet been made of New Zealand. Nevertheless, in the intervals between an examination of the mines and mining districts Sir James Hector managed to get a sketch-map made of the greater part of the country, while some of the more important districts had been examined in detail. A good deal was known about the general geological structure of New Zealand, but it was not known accurately. While something had been done towards unravelling the geological structure of the colony, the palæontology had been sadly neglected. Nearly all we knew about the palæontology was either due to the Government of Austria or the result of private enterprise. The large collections that had been made by the Survey Department had never been classified, and were practically wasted owing to the apathy of the Government. It was a great pity that this should be so, for the geographical position of New Zealand gave to its geology a world-wide interest. It was in New Zealand alone that we had any record of the ancient flora and fauna that

overspread the South Pacific. Captain Hutton proceeded to say that he thought all geologists who had examined New Zealand were pretty well agreed on most points of its geological history. There were only a few points on which they differed. He then went on to give details as to the general geological structure of New Zealand, and referred to the conclusions to be drawn from a study of these details. In concluding, he referred to the fact that the great river-gorges in Central Otago had been cut out by the action of glaciers. He also mentioned the well-known fact that Lake Wakatipu formerly overflowed at the Kingston end, but owing to the formation of a huge moraine which blocked up that exit the outlet by means of the Kawarau was formed. In this connection, he observed that he did not know if there were any persons present interested in mining, but he might say that the Molyneux Gorge was some two million years old, while the Kawarau Gorge was only about two hundred thousand. They would know what that meant.

Annual Meeting: *15th November, 1899.*

Mr. F. R. Chapman, President, in the chair.

New Member.—Mr. Meggitt.

The Hon. Secretary, Mr. A. Hamilton, read a paper by Professor Ulrich on a Tasmanian rock resembling leucite syenite porphyry.

The base of the rock is of a syenite type, and in it occur porphyritically distributed yellowish-brown crystals (trapezohedrons), which under the microscope, in polarised light with crossed nicols, have, in thin sections, exactly the same double refraction as leucite. From the fact of its fusion very easily to a magnetic globule, the crystals appear to be garnet, which exhibit the hitherto unrecorded property of occurring in twinned form, resembling leucite. Chemical examination of the rock confirms this conclusion.

Abstract of Annual Report.

Nine meetings of the Council have been held, and six meetings of members, at which fifteen papers were read.

The Council were able to arrange with Captain Hutton, F.R.S., to come down from Christchurch and give a lecture on the "Geological History of New Zealand."

Two members of the Council resigned on leaving the district—Mr. B. C. Aston and Mr. J. S. Tennant. Their places were filled by Mr. J. Barningham, and Mr. Crosby Smith was appointed treasurer.

Early in the session an important discovery was made, on the Molyneux, of a perfect specimen of a moa's egg, and at the February meeting the President (Mr. F. R. Chapman) stated that Mr. Alexander Black had purchased the egg, and had offered it to the Institute on very liberal terms. He also said that a letter had been sent to the Council of the University, stating that the Institute would undertake to make the purchase from Mr. Black if the University Council would agree to become responsible for the £45 required to complete the purchase, and to refund the same within three years at the rate of £15 per annum. The University Council, having considered the matter, expressed their thanks to the President of the Institute for his prompt action, and agreed to the terms

suggested. Mr. A. Black made over the egg at the price he paid for it—namely, £50—and gave £5 towards liquidating the amount. The Institute also agreed to give £5 from its funds towards that object, thus leaving a balance of £40 to be paid by the University, and the term of repayment was extended to four years. The egg in the meantime is deposited in the Museum of the University of Otago by the President of the Otago Institute. Several members of the Council expressed their gratification at the public spirit shown by Mr. Black in securing the egg and contributing towards its purchase, and the following resolution was unanimously passed: "That the Council hereby records its appreciation of the public-spirited action of Mr. Alexander Black, of Dunedin, engineer, in securing for the Otago Museum the moa's egg recently obtained from the banks of the Molyneux, and hereby resolves that Mr. Black be placed on the list of life-members of the Otago Institute."

In the matter of the Purakanui Fish-hatchery and Biological Station, the Committee on that subject again visited the locality with Mr. Ayson, and he appeared to consider it a suitable spot, but pointed out that it would be desirable to have various data collected before further steps were taken. We are now informed by Mr. J. A. Millar, M.H.R., that the Government intend to proceed with the establishment of the projected station; but up to the present time no definite steps have been taken.

A list of volumes added to the Library is appended. They are principally on the *Annelida*, in accordance with the resolution expressed in last year's report, that special groups of the animal kingdom should receive attention each year.

The scheme of offering prizes for natural-history notes to be made by children attending the Board schools in the educational district was received by the Education Board, and referred to their Inspectors and the Educational Institute for a report. After waiting for some time for them to adopt the scheme, it was deemed advisable to withdraw the matter from the Board, and to offer the prizes through the columns of an educational journal circulating in the district. After modifying certain of the conditions this course was adopted, although the Council would much have preferred having the support of the Education Board in a matter which had for its aim the development of the faculty of observation in children.

The balance-sheet shows that the receipts for the year, including a balance brought forward of £43 14s., amount to £130 17s. The expenses were £123 2s. 7d., leaving a balance of £7 14s. 5d. in hands of the bank.

Election of Officers for 1900.—*President*—E. Melland; *Vice-presidents*—F. R. Chapman, Alexander Bathgate; *Council*—Dr. Hocken, Dr. Barnett, G. M. Thomson, A. Hamilton, J. Barningham, C. W. Chamberlain, F. B. Stephens; *Hon. Secretary*—Professor W. B. Benham; *Hon. Treasurer*—J. Crosby Smith; *Auditor*—D. Brent.

The retiring President then delivered an address on "Federation."

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

First Meeting: *8th May, 1899.*

The President delivered his inaugural address, taking as his subject "The Sun and the Moon, with a Descriptive Account of the late Total Eclipse of the Sun."

The address was illustrated by a number of lantern-slides.

Second Meeting: *12th June, 1899.*

Papers.—1. "Hawke's Bay Fisheries," by W. Dinwiddie.

2. "Exploration," by J. Caughley.

Third Meeting: *14th August, 1899.*

Papers.—1. "The Geology of the District between Napier and Puketitiri," by H. Hill. (*Transactions*, p. 183.)

2. "The Evidences of Darwinism," by W. Dinwiddie.

Fourth Meeting: *11th September, 1899.*

Mr. Hill delivered the first part of a lecture on "Evolution."

The lecture was illustrated by numerous lantern-slides.

Fifth Meeting: *18th September, 1899.*

Mr. Hill concluded his lecture on "Evolution."

SIXTH MEETING: *2nd October, 1899.*

The President delivered a lecture on "Development by Creation as opposed to the Theory of Development by Evolution."

The lecture was illustrated by a number of lantern-slides.

SEVENTH MEETING: *16th October, 1899.*

Papers.—1. "Flowers in Relation to Insects," by T. C. Moore, M.D.

2. "Inherited Instincts and Anecdotes of Domestic Animals," by Taylor White. (*Transactions*, p. 272.)

EIGHTH MEETING: *15th December, 1899.*

Dr. Milne-Thomson delivered a lecture on "Round the South Sea Islands."

The lecture was illustrated by a number of slides from photographs taken by the lecturer.

ANNUAL MEETING: *9th February, 1900.*

ABSTRACT OF ANNUAL REPORT.

During the session six ordinary and three extraordinary meetings were held, and at these meetings seven papers were read and five lectures delivered. The lectures in particular were well attended.

The Council held sixteen meetings during the year, and transacted a large amount of general business.

The Council regret to report that by death the Institute lost two of its oldest members—Rev. William Colenso, F.R.S., F.L.S., and Mr. John Harding. Several others have withdrawn from membership, but a number of new members have been elected, and the roll shows an increase of two, making a total of sixty-two. By his will the late Mr. Colenso left to the Institute, for the benefit of the Museum and library, the sum of £200, as well as all his dried plants, and zoological and other wet natural-history specimens, and several of his pictures. The Council placed the sum of £75 on fixed deposit, and decided to spend the remainder on books and a lantern. Ninety-four volumes (including two fine volumes of "Archæological Essays," presented by Mr. J. W. Craig) have been added to the library, and a first-class lantern has been ordered, and is expected in time for the work of the coming session. A portion of the money was also spent in the purchase of a microscope, which is now available for the use of members. In connection with Mr. Colenso's death the following resolution had been passed by the Institute: "That this branch of the New Zealand Institute places upon record the great

loss it has sustained by the death of the Rev. William Colenso, F.R.S., F.L.S., who from its foundation was closely connected with the society as secretary, president, and member of the Council, and, as a contributor of papers on botany, anthropology, and kindred subjects, has done much for the advancement of science throughout the world."

The science classes inaugurated two years ago were continued during the past year, but did not meet with the support they deserved. Dr. Milne-Thomson kindly undertook the electricity class.

The balance-sheet showed that the total receipts (including a balance of £23 14s. 1d. from the preceding year) were £97 8s. 7d., and the expenditure £74 15s., leaving a balance in hand of £22 13s. 7d. The total assets are valued at £847 8s. 7d. Of the Colenso bequest of £200, a balance of £103 8s. remained in hand.

ELECTION OF OFFICERS FOR 1900.—*President*—W. Dinwiddie; *Vice-president*—T. Hall; *Council*—J. E. H. Jarvis, M.R.C.S., J. Caughley, H. Hill, B.A., F.G.S., F. A. Tregelles, T. Tanner, T. C. Moore, M.D.; *Hon. Secretary*—James Hislop; *Hon. Treasurer*—J. W. Craig; *Hon. Auditor*—G. White.

WESTLAND INSTITUTE.

The annual meeting was held in the library, the attendance being fairly good.

ABSTRACT OF ANNUAL REPORT.

The report dealt exhaustively with its past and present, including some allusions to its future requirements. The Borough Council was gratefully thanked for their annual subsidy, likewise the Harbour Board for their welcome donation. The members' roll was reported to contain fifty-nine names, though the income from paying members is the best criterion of the strength of the society. The trustees have held nine monthly meetings, the average attendance being seven. The library still maintains its popularity, and a welcome addition of 118 volumes has been made; it is to be hoped that another increase will be gained during the current year. The reading-room has been well supplied with papers, and is much frequented. The trustees take the present opportunity of thanking those proprietors who so kindly donate their papers for its benefit.

The trustees record their deep sense of the loss of the late Mr. A. H. King, who for many years took the greatest interest in and whose services were many for the benefit of the society.

The balance-sheet showed—Receipts, £113 6s. 8d.; expenditure, £101 12s. 5d.: leaving a credit balance of £11 14s. 3d.

ELECTION OF OFFICERS FOR 1900.—*President*—Mr. A. J. Morton; *Vice-president*—Mr. A. Mahan; *Hon. Treasurer*—Mr. G. K. Sinclair; *Trustees*—Messrs. Clarke, Dawes, Perry, Macfarlane, McNaughton, Michel, Beare, Solomon, Park, Lewis, Drs. Macandrew and Teichelmann.

NELSON PHILOSOPHICAL SOCIETY.

First Meeting: *8th August, 1899.*

The Bishop of Nelson, President, in the chair.

A proposal from the Nelson Institute reading-room committee suggesting amalgamation with the Philosophical Society was discussed and eventually agreed to on certain conditions, one of which was that the Nelson Institute should first apply for and obtain incorporation with the New Zealand Institute.

Second Meeting: *13th November, 1899.*

The Bishop of Nelson, President, in the chair.

Paper.—"On the Formation of the Nelson Boulder Bank," by W. T. Worley. (*Transactions*, p. 221.)

The author's theory was that it was formed from the denudation of an ancient elevated ridge, of which the Arrow Rock once formed a part.

In the discussion which followed, the author's theory was fully criticized.

Mr. C. Coleridge Farr, B.Sc., gave an exhibition of the magnetic and meteorological instruments used in his magnetic survey of the coasts of New Zealand.

An interesting description of each instrument was given, with a demonstration of the method of using it in the work of taking observations.

It was stated at the meeting that the proposed amalgamation considered at a previous meeting had been postponed indefinitely.

Annual Meeting: *13th March, 1900.*

The Bishop of Nelson, President, in the chair.

New Member.—Captain Cox, Nelson.

ABSTRACT OF ANNUAL REPORT.

One ordinary meeting and one special meeting were held during the year. The attendance at the ordinary meeting was very good.

One paper was read and one address delivered. A proposal to amalgamate with the Nelson Institute Library, with a view to strengthen the membership of the Society, was brought forward, but postponed.

The balance-sheet showed that the total receipts, inclusive of a balance of £9 13s. 3d. from the preceding year, were £20 3s. 3d., while the expenditure was, on the Museum, £3 5s.; Society's library, &c., £3 6s.: leaving a balance in hand of £13 12s. 3d.

ELECTION OF OFFICERS FOR 1900.—*President*—The Bishop of Nelson; *Vice-presidents*—A. S. Atkinson and Dr. Mackie; *Hon. Secretary*—R. I. Kingsley; *Hon. Treasurer*—Dr. Hudson; *Hon. Curator*—R. I. Kingsley; *Assistant Curator*—E. Lukins; *Council*—The first five *ex officio*, and F. G. Gibbs, E. Lukins, Dr. Boor, Rev. F. Chatterton, and J. G. Bartel.

APPENDIX

METEOROLOGY.

Comparative Abstract for 1899 and Previous Years.

Stations.	Barometer at 9.30 a.m.		Temperature from Self-registering Instruments read in Morning for Twenty-four Hours previously. Fahr.					Computed from Observations.		Rain.		Wind.		Cloud.
	Mean Reading.	Extreme Range.	Mean. Temp. in Shade.	Mean Daily Range of Temp.	Extreme Range of Temp.	Max. Temp. in Sun's Rays.	Min. Temp. on Grass.	Mean Elastic Force of Vapour.	Mean Degree of Moisture (Saturation = 100).	Total Fall in Inches.	No. of Days on which Rain fell.	Average Daily Force in Miles for Year.	Maximum Velocity in Miles in any 24 hours, and Date	Mean Amount (0 to 10).
Auckland...	30·013	1·020	58 7	12·3	47·5	144·0	33·0	0 350	69	34·440	151	...	..	4.9
Previous 35 years ...	29 997	...	58·9	...	...	...	...	0 381	72	42·102	181	...	...	.
Wellington	29·966	1 542	54·7	12·3	45·3	141·0	23·0	0·306	71	52 715	181	207	700 on 31st Jan. and 11th Oct.	4·4
Previous 35 years ...	29·927	...	54·8	...	...	...	...	0·331	72	50 981	161	.		...
Dunedin	29·881	1·632	49·8	14·3	58·0	...	22 0	0 277	76	38 621	159	153	570 on 17th Nov.	5·2
Previous 35 years ...	29 955	...	50·0	...	...	...	...	0·274	73	36 867	157	...		...

Average Temperature of Seasons compared with those of the Previous Year.

Stations.	Spring. September, October, November.		Summer. December, January, February.		Autumn. March, April, May.		Winter. June, July, August.	
	1898.	1899.	1898.	1899.	1898.	1899.	1898.	1899.
Auckland	57 2	57·0	64·7	65·7	66·1	60 6	52·8	51·6
Wellington	54·3	54·3	61·5	60·9	56·2	56·8	48·7	46 9
Dunedin	49·7	50·3	56·5	56·5	50·1	51·0	42·3	41·7

REMARKS ON THE WEATHER DURING 1899.

JANUARY.—Heavy rain generally during this month, and strong winds prevailing from N.W. over centre; changeable weather in South.

FEBRUARY.—Fine in North, but heavy rain over centre in early part of month; in South unsettled. Moderate winds.

MARCH.—In North fine in early part, but strong N.E. gales in latter, with rain; over centre generally showery, moderate winds, or calm; in South showery, with light winds.

APRIL.—Generally fine in North, and heavy showers of rain in latter part over centre and in South; moderate winds.

MAY.—Fine in North; very wet over centre, and strong S.E. winds; frequent fogs. Changeable and showery in South, with prevailing S.W. winds and moderate.

JUNE.—Strong N.E. winds in North, and heavy rain at intervals; over centre damp unpleasant weather, but small total rainfall, moderate or light winds, frequent fogs; in South very fine, with light winds.

JULY.—In North fine in middle of month, but otherwise wet weather and prevailing S.W. winds and often strong; centre, heavy rains from N.W. and S., frequent hail and fog; in South unpleasant changeable weather, prevailing S.W. winds.

AUGUST.—In North generally fine, but severe gale 14th to 19th from E. and S.E.; over centre generally fine frosty weather, moderate winds; in South light showers and pleasant weather.

SEPTEMBER.—Fine in North, with moderate S.W. winds; over centre very wet latter part, and severe hail-storm on 30th; in South generally fine.

OCTOBER.—In North a wet month, prevailing S.W. wind and strong at times; over centre fine but variable weather, prevailing N.W. wind and frequently strong; in South fine, with occasional light showers, prevailing S.W. wind.

NOVEMBER.—In North generally fine, but some strong gales from S.W. and N.E.; over centre fine, though showery at times, prevailing N.W. winds and often strong; in South very showery weather, and prevailing S.W. winds.

DECEMBER.—In North a very fine, dry, pleasant month; over centre wet early part, but fine during latter, prevailing strong N.W. winds; in South showery unpleasant weather, with cold S.W. winds.

EARTHQUAKES reported in NEW ZEALAND during 1899.

PLACE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Taupo ..	..	..	..	30	..	..	..	..	..	..	..	..	1
Tokaanu† ..	..	..	..	..	..	..	..	..	8*	..	..	..	1
Rotorua ..	..	..	..	..	..	..	..	..	..	16	..	..	1
Napier ..	..	..	..	..	..	..	..	..	..	16*	..	..	1
Gisborne ..	..	..	..	..	1	..	..	..	..	..	..	..	1
New Plymouth	..	..	22, 27	..	27	29	..	..	5	..	..	4	6
Masterton ..	..	..	..	..	20	..	..	..	..	..	..	..	1
Mauriceville..	..	..	..	..	20*	..	..	..	..	..	..	..	1
Eketahuna ..	..	..	..	..	..	..	..	29*	..	..	..	..	1
Wellington ..	..	..	..	16	22	..	..	6	..	..	..	4	4
Alfredton ..	..	..	..	..	..	..	..	29*	..	..	..	..	1
Newman ..	..	..	..	..	..	..	..	29*	..	..	..	..	1
Nelson ..	..	..	..	..	..	..	..	6	..	..	..	..	1
Christchurch	..	..	..	..	..	..	6*	..	..	..	..	..	1
Lyttelton ..	..	..	..	..	..	..	6*	..	..	..	..	..	1
Ashburton ..	..	..	..	..	..	26	..	..	..	..	..	..	1
Dunedin ..	..	..	..	..	..	..	..	11	..	..	..	..	1
Arrowtown ..	..	..	..	..	..	..	..	18*	..	..	..	..	1

NOTE.—The figures denote the day of the month on which one or more shocks were felt. Those with the asterisk affixed were described as *smart*. The remainder were only slight tremors, and no doubt escaped record at most stations, there being no instrumental means employed for their detection, except at Wellington, which is the only station at which a seismograph records the shocks. These tables are therefore not reliable as far as indicating the geographical distribution of the shocks.

† Several shocks occurred during September in this locality.

NEW ZEALAND INSTITUTE.

HONORARY MEMBERS.

1870.

Finsch, Otto, Ph.D., of Bremen.
Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S.

1873.

Cambridge, The Rev. O. Pickard, M.A., C.M.Z.S.
Günther, A., M.D., M.A., Ph.D., F.R.S.

1874.

McLachlan, Robert, F.L.S.
Newton, Alfred, F.R.S.

1875.

Sclater, Philip Lutley, M.A., Ph.D., F.R.S.

1876.

Etheridge, Prof. Robert, F.R.S.
Berggren, Dr. S.

1877.

Sharp, Dr. D.

1878.

Müller, Professor F. Max, P.C., F.R.S.

1883.

Lord Kelvin, G.C.V.O., D.C.L., F.R.S.
Ellery, Robert L. J., F.R.S.

1885.

Sharp, Richard Bowdler, M.A., F.L.S.
Wallace, A. R., F.L.S.

1890.

Nordstedt, Professor Otto, Ph.D.
Liversidge, Professor A., M.A., F.R.S.

1891.

Goodale, Professor G. L., M.D., LL.D.
Davis, J. W., F.G.S., F.L.S.

1894.

Dyer, Sir W. T. Thiselton, K.C.M.G., C.I.E., LL.D., M.A., F.R.S.
Codrington, Rev. R. H., D.D.

1895.

Mitten, William, F.L.S.

1896.

Lydekker, Richard, B.A., F.R.S.
Langley, S. P.

1900.

Agardh, Dr. J. G.
Lubbock, Sir J., Bart., P.C., F.R.S.
Massee, George, F.L.S., F.R.M.S.

ORDINARY MEMBERS.

WELLINGTON PHILOSOPHICAL SOCIETY.

[* Life-members.]

Adams, Dr.
Allen, F.
Atkinson, A. R.
Atkinson, A. S., Nelson
Baldwin, P. E.
Barker, G. H.
Barnes, R. J.
Barraud, W. F.
Barton, W.
Batkin, C. T.
Beetham, G.
Beetham, W. H.
Bell, E. D.
Bell, H. D.
Best, E., Hadfield
Blair, J. R.
Bothamley, A. T.
Brandon, A. de B.
Brown, W. R. E.
Buller, Sir W. L., K.C.M.G. D.Sc., F.R.S.
Caldwell, R.
Campbell, J. P.
Chapman, Martin
Chapple, Dr.
Chudleigh, E. R.
Cohen, W. P.
Connal, E.
Davy, Dr. T. G., Kumara
Dawson, B.
Denton, George
Drew, S. H., Wanganui
Elliot, Major E. H. J.
Evans, W. P., M.A., Ph.D.
Ewart, Dr.
Ewen, C. A.
Farquhar, H.
Ferard, B. A., Napier
Ferguson, W., C.E.
Field, H. C., Wanganui
Fraser, F. H.
Freeman, H. J.
Gifford, A. C.
Gordon, H., F.G.S.
Gore, R. B.
Grace, Hon. M. S., C.M.G., M.D.
Hadfield, E. F.
Hanify, H. P.
Harcourt, J. B.
Harding, R. Coupland
Hastie, Miss J. A.*
Hawthorne, E. F.
Haylock, A.
Hector, Sir James, K.C.M.G., M.D., F.R.S.
Henley, J. W.
Herbert, W. H.
Hislop, Hon. T.
Hogben, G., M.A.
Holmes, R. L., F.R. Met. Soc., Fiji*
Holmes, R. T., Masterton
Hudson, G. V., F.E.S.
Hustwick, T. H.
Inwood, D., Canterbury
Jenkins, Digby A.
Johnson, G. Randall*
Joynt, J. W., M.A.
Kenny, Hon. Captain C.
King, T.
Kirk, H. B., M.A.
Kirk, T. W., F.L.S.
Krull, F. A., Wanganui
Lambert, T. S.
Lee, H. M.
Lee, R.
Liffiton, E. N., Wanganui
Litchfield, A. J., Blenheim
Lomax, H. A., Wanganui
Mackenzie, F. Wallace, M.B.
Maclaurin, Prof. R. C., M.A.
Marchant, J. W. A.
Martin, Dr. A.

Mason, Thomas, Hutt
Masters, Rev. F. G.
Maxwell, J. P., M.Inst.C.E.
McDougall, A.
McKay, Alexander, F.G.S.
McLeod, H. N.
McWilliam, Rev. J., Otaki
Mestayer, R. L., M.Inst.C.E.
Molineaux, B. M.
Moore, G.
Moorehouse, W. H. S.
Morison, C. B.
Murdoch, R., Wanganui
Nairn, C. J., Hawke's Bay
Newman, Alfred K., M.B., M.R.C.P.
Newman, E. W.
Orr, Robert
Park, R. G.*
Pearce, E.
Pharazyn, C., Wairarapa
Phillips, Coleman
Pierard, C. H.
Pollen, Hugh
Powles, C. P.
Poynton, J. W.
Prendergast, Sir J.
Pringle, T.
Purdy, Dr. J. S.
Reid, W. S.
Richardson, C. T.
Rowse, Rev. W., Greytown
Roy, R. B., New Plymouth*
Rutherfurd, A. J.
Rutherfurd, W. G.
Rutland, Joshua, Marlborough
Samuel, E.
Schaw, Major-General, C.B., R.E.
Simcox, W. H., Otaki
Sinclair, J.
Singer, J., F.C.S.
Skerman, Dr. Sydney, Marton
Skey, W.
Smith, Charles, Wanganui
Smith, M. C.
Smith, S. Percy, F.R.G.S.
Stewart, J. T., Wanganui
Stowell, H. M.
Stuart, A. P.
Tait, P. W.
Talbot, Dr. A. G.
Tanner, Cyril
Travers, W. T. L., F.L.S.
Tregear, E.
Turnbull, A. H.
Turnbull, R. T.
Turnbull, Thomas
Waley, A. S., London
Wallace, James
Waterhouse, G. M., F.R.G.S.
Welch, W., Palmerston N.
Wilton, G. W.
Woodhouse, Alfred James, London
Young, J.

AUCKLAND INSTITUTE.

[*Honorary and life members.]

Adams, J., B.A., Thames
Aickin, G., Auckland
Aitken, W. ,,
Argall, W. H., Coromandel
Bagnall, L. J., Thames
Bakewell, R. H., M.D., Auckland
Ball, W. T., Auckland
Bartley, E., Devonport
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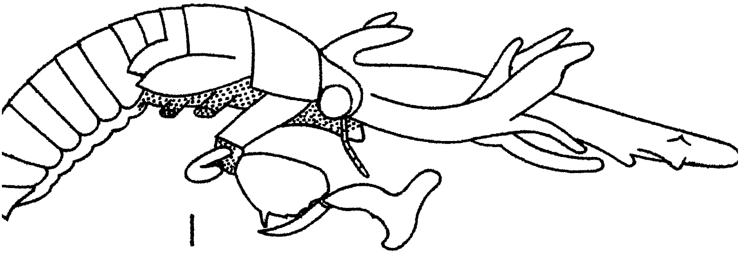

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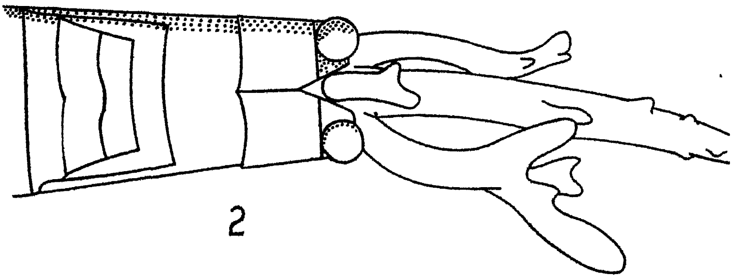

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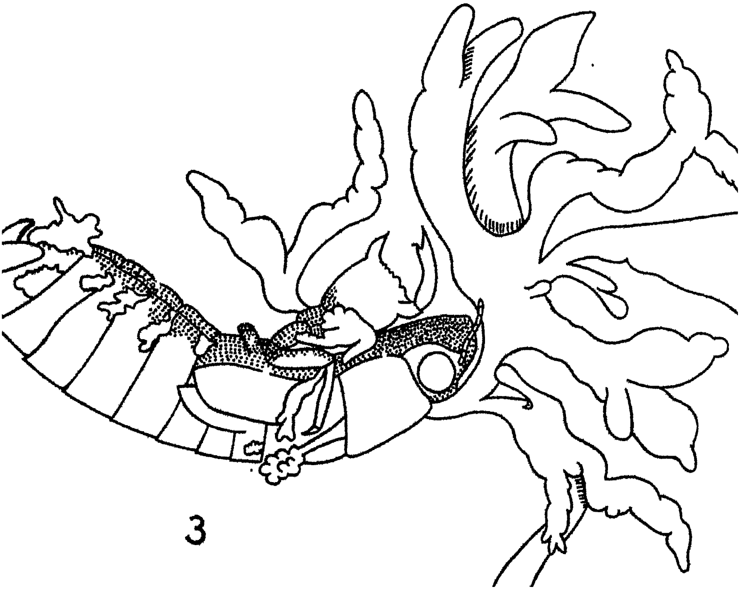

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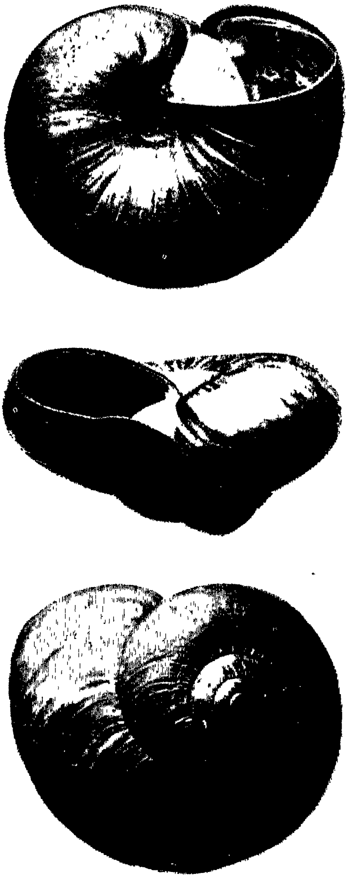

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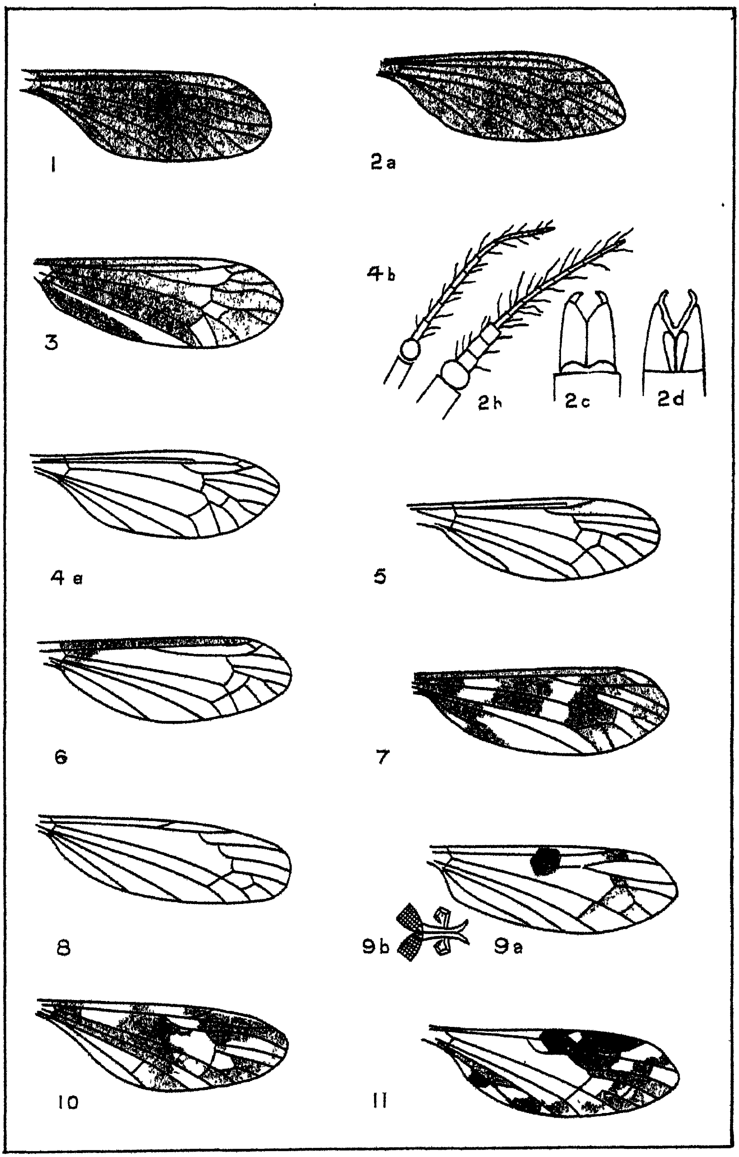

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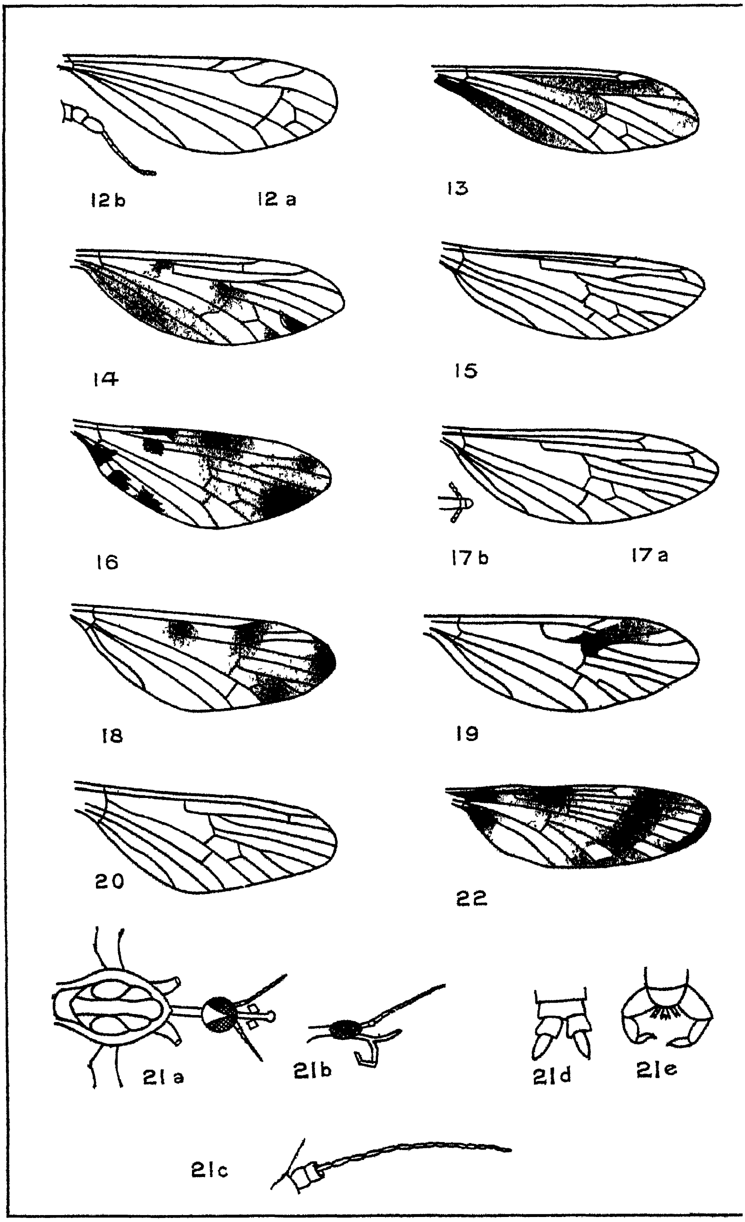

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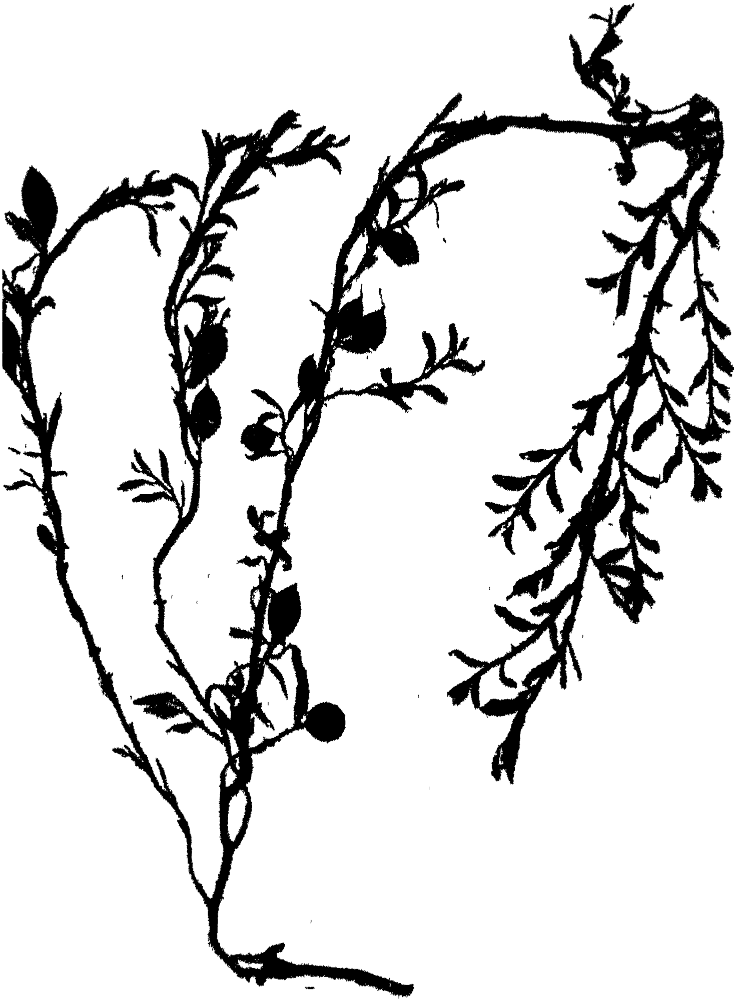


FIG. 1.

NEW ZEALAND SEAWEEDS

(Laing)

FIG. 2

NEW ZEALAND SEAWEEDS

(Laing)

FIG. 1.

NEW ZEALAND SEAWEEDS

(Laing)

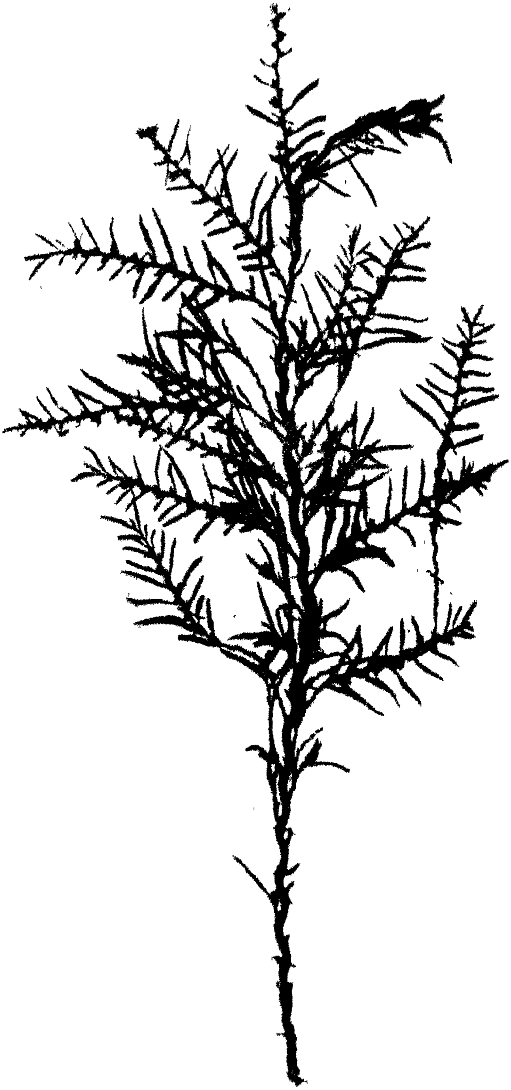


FIG. 2

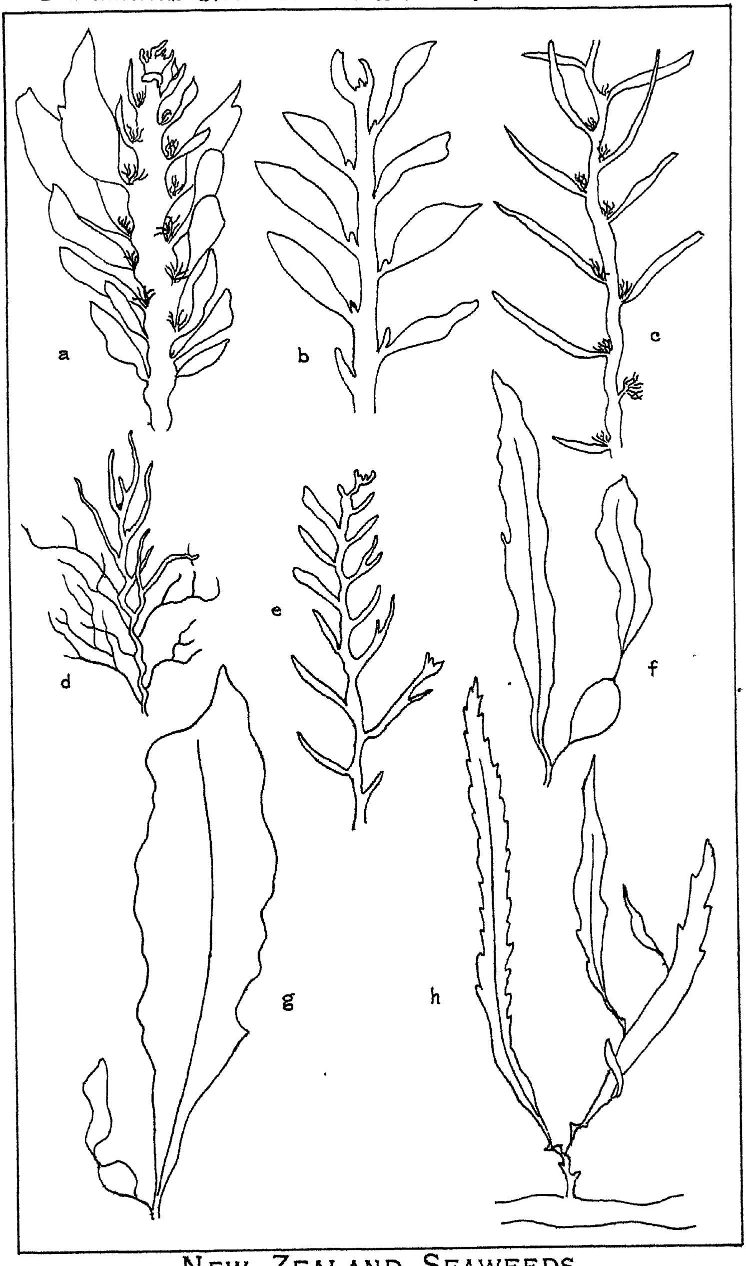
NEW ZEALAND SEAWEEDS

(Laing)

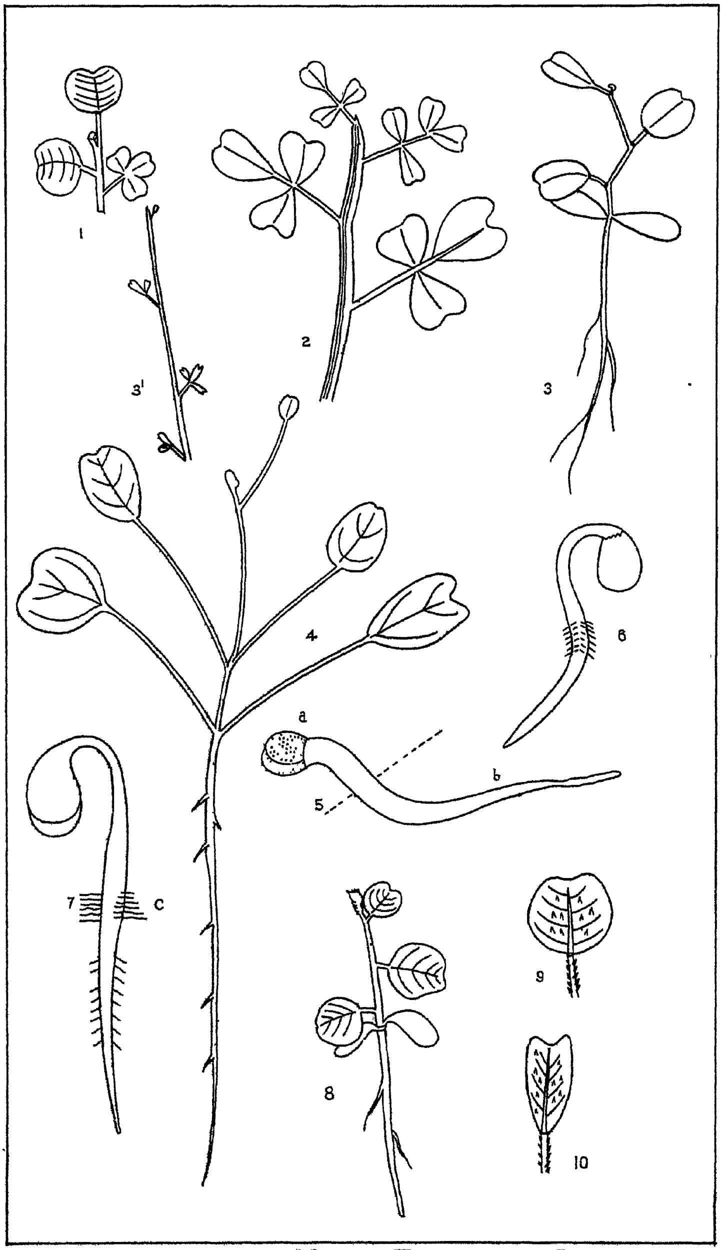
FIG. 3

NEW ZEALAND SEAWEEDS

(Laing)

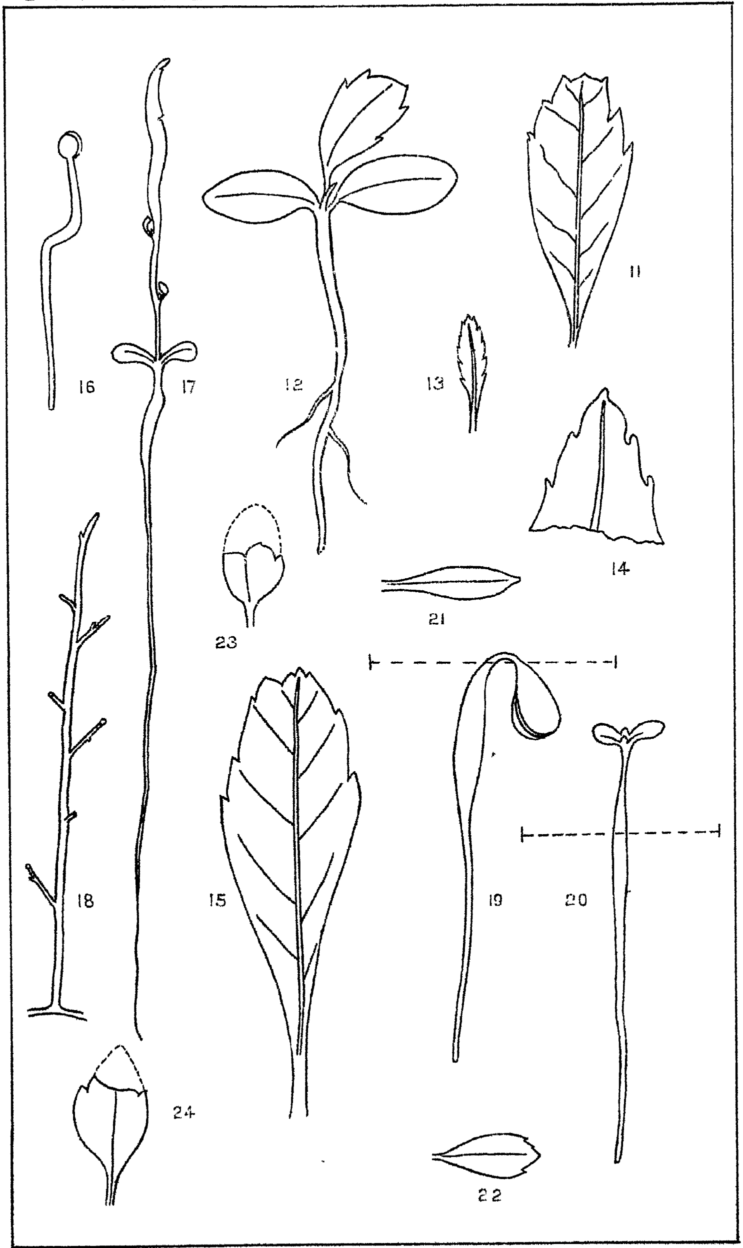


NEW ZEALAND SEAWEEDS
(Laing)



SEEDLINGS OF NEW ZEALAND PLANTS.

(Cockayne)



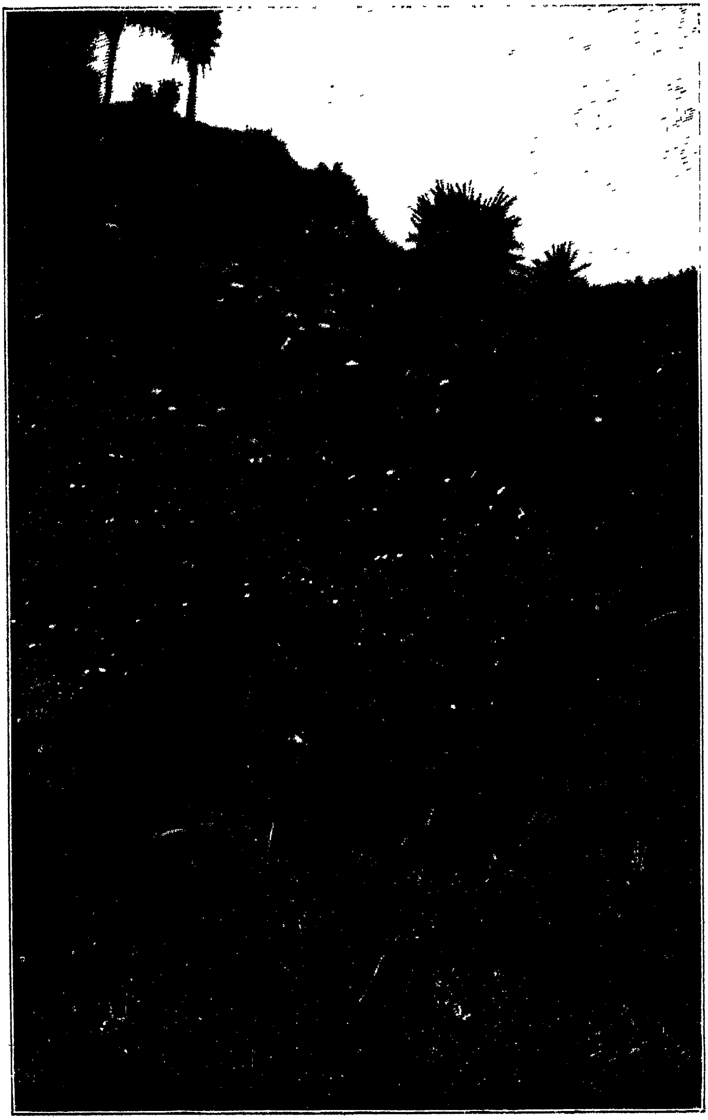
SEEDLINGS OF NEW ZEALAND PLANTS.

(Cockayne)

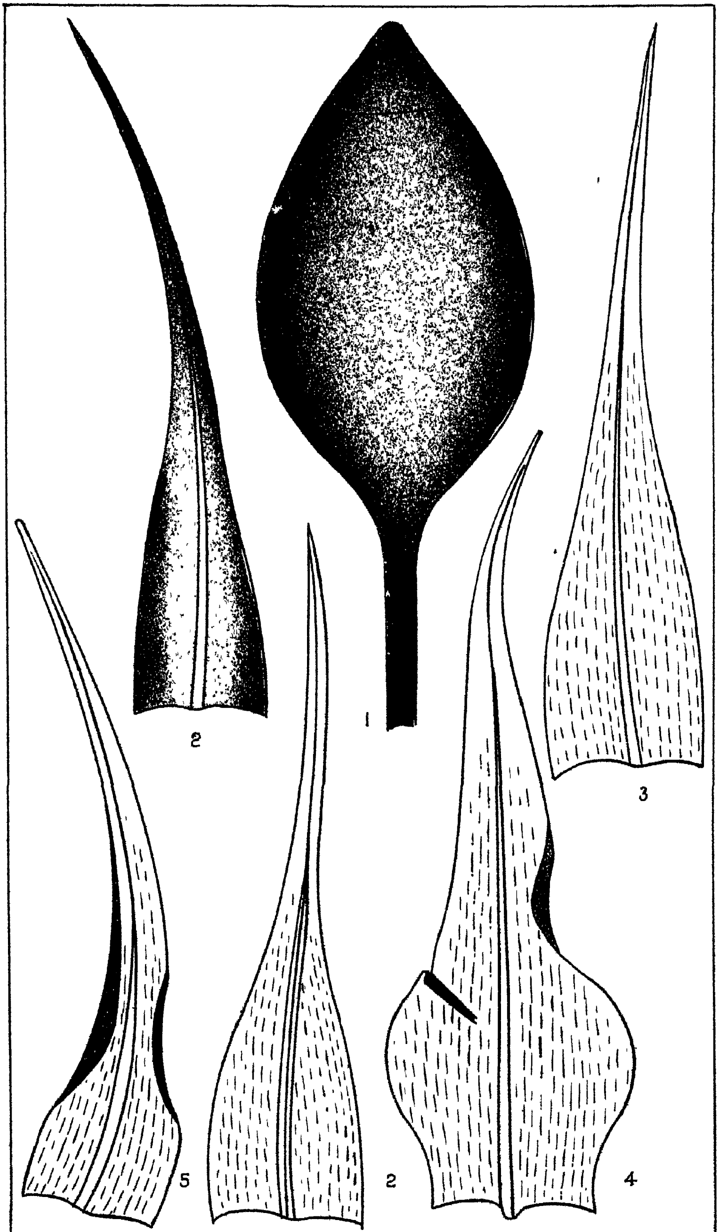
A SUBALPINE MEADOW
(Cockayne)

RAOULIA EXIMIA
(Cockayne)

RAOULIA EXIMIA
(Cockayne)

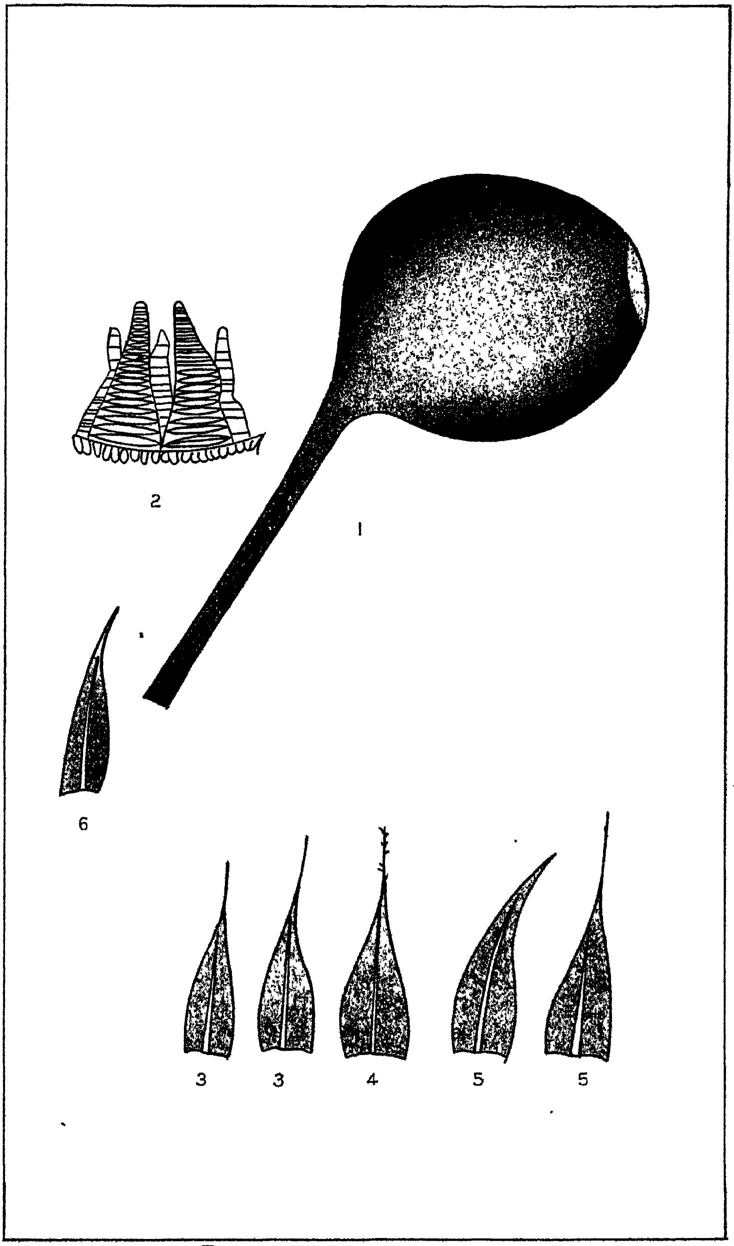


TERRACE OF RIVER WAIMAKARIRI
(Cockayne)



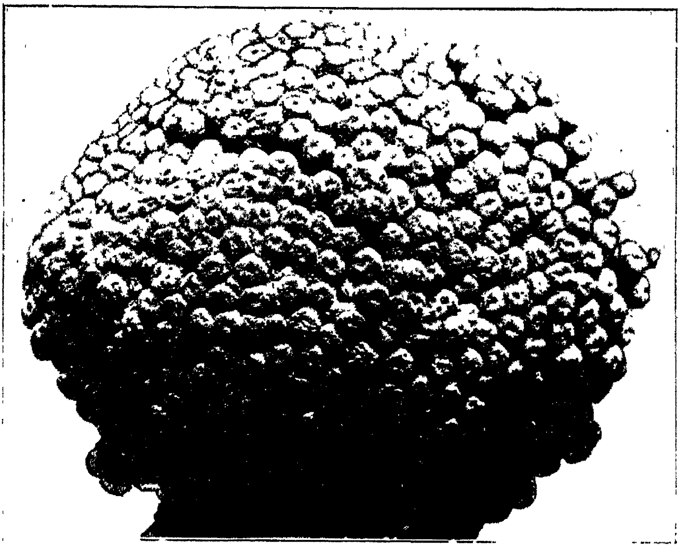
BARTRAMIA ROBUSTIFOLIA

(Brown)

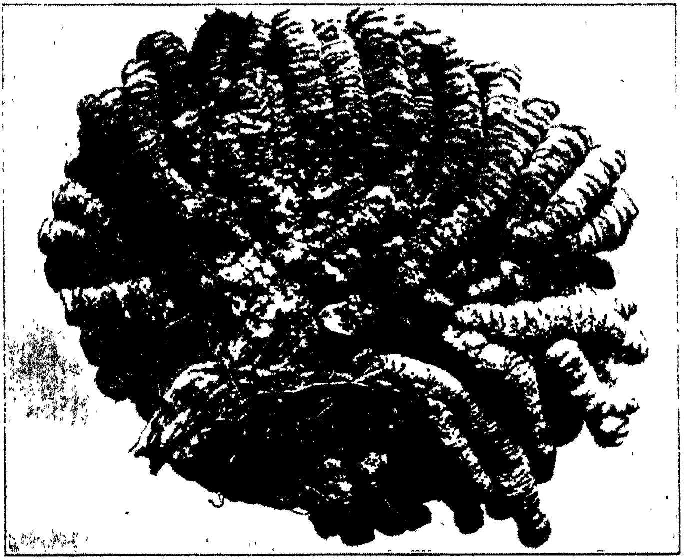


BARTRAMIA HAPUKA.
(Brown)

STIRTONIA MACKAYI.
(Brown)

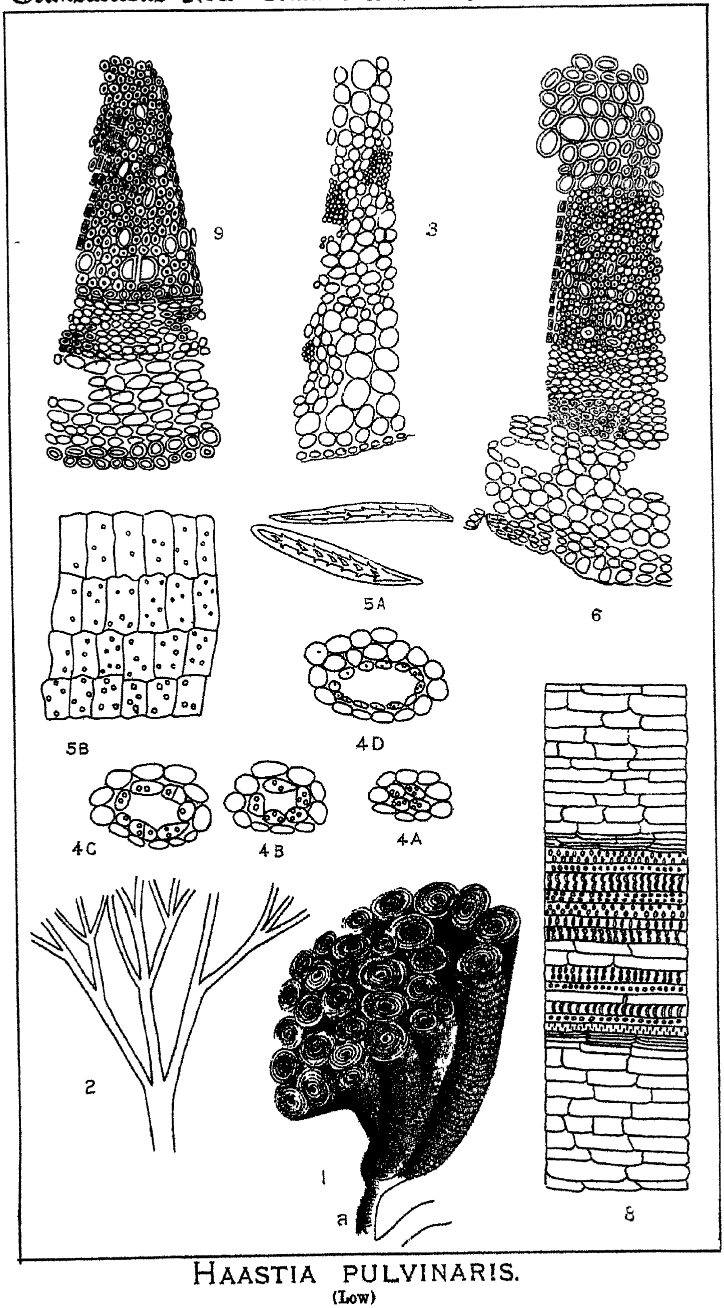


Front View

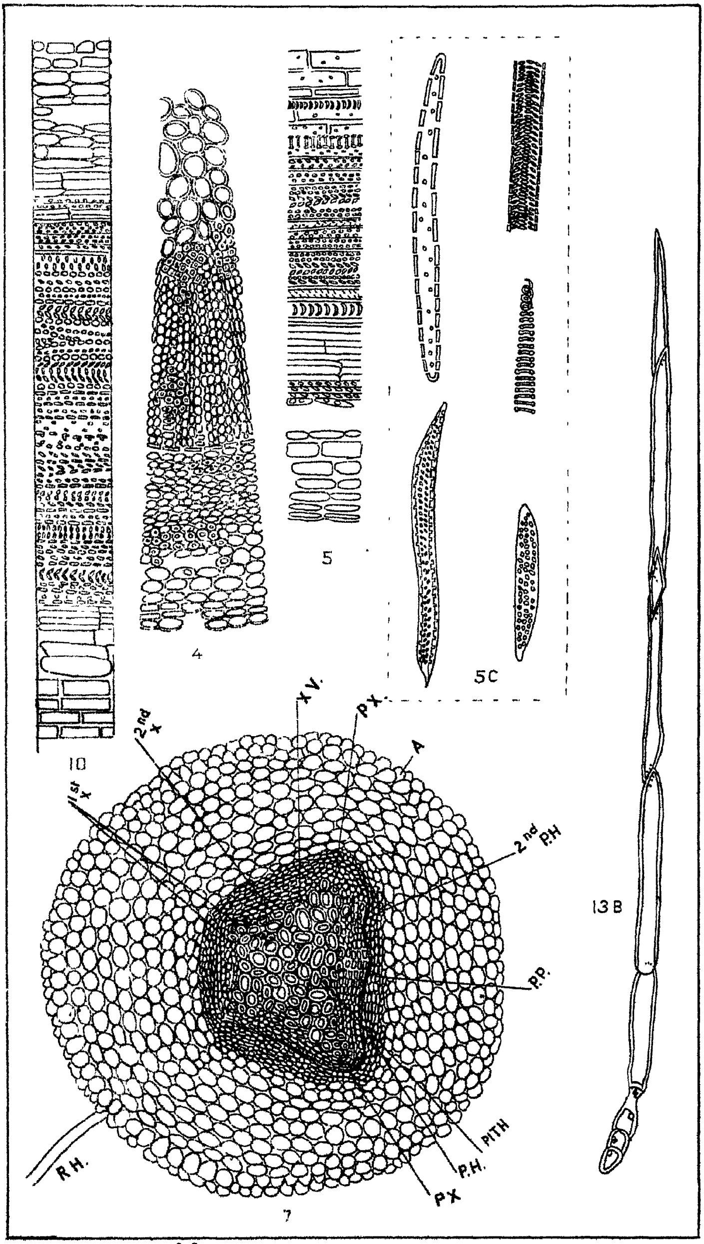


Back View

HAASTIA PULVINARIS
(Low)

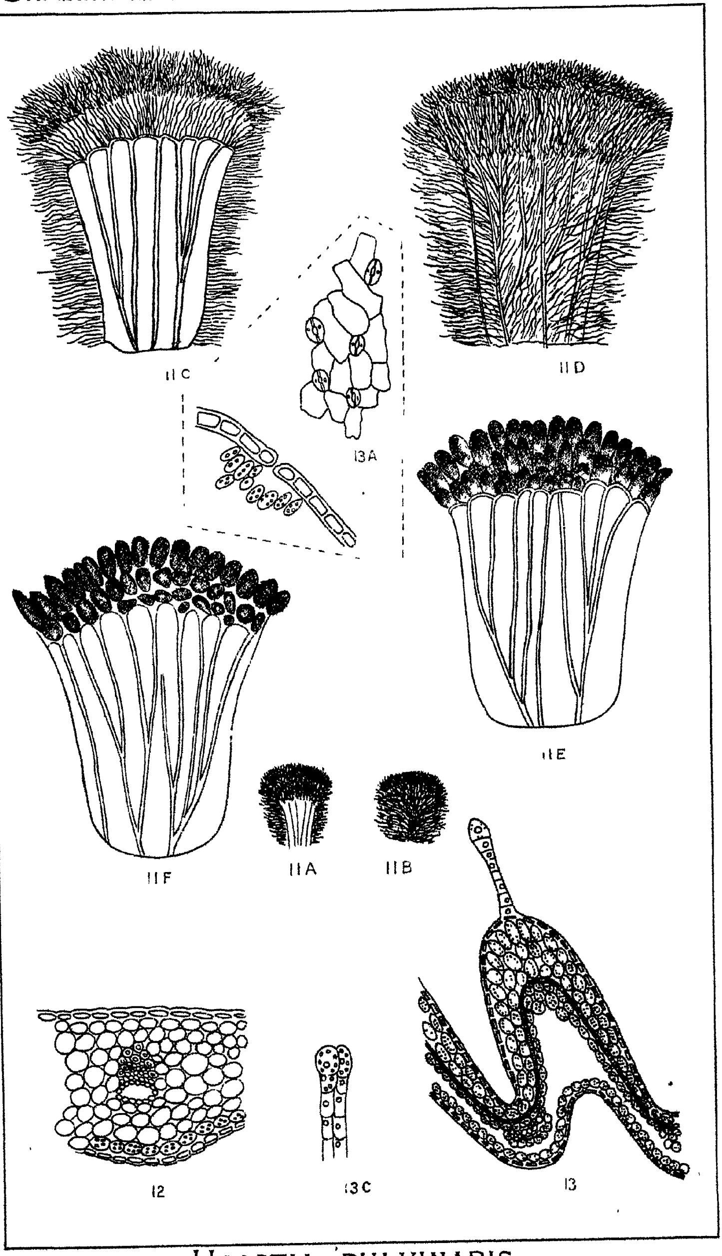


HAASTIA PULVINARIS.
(Low)



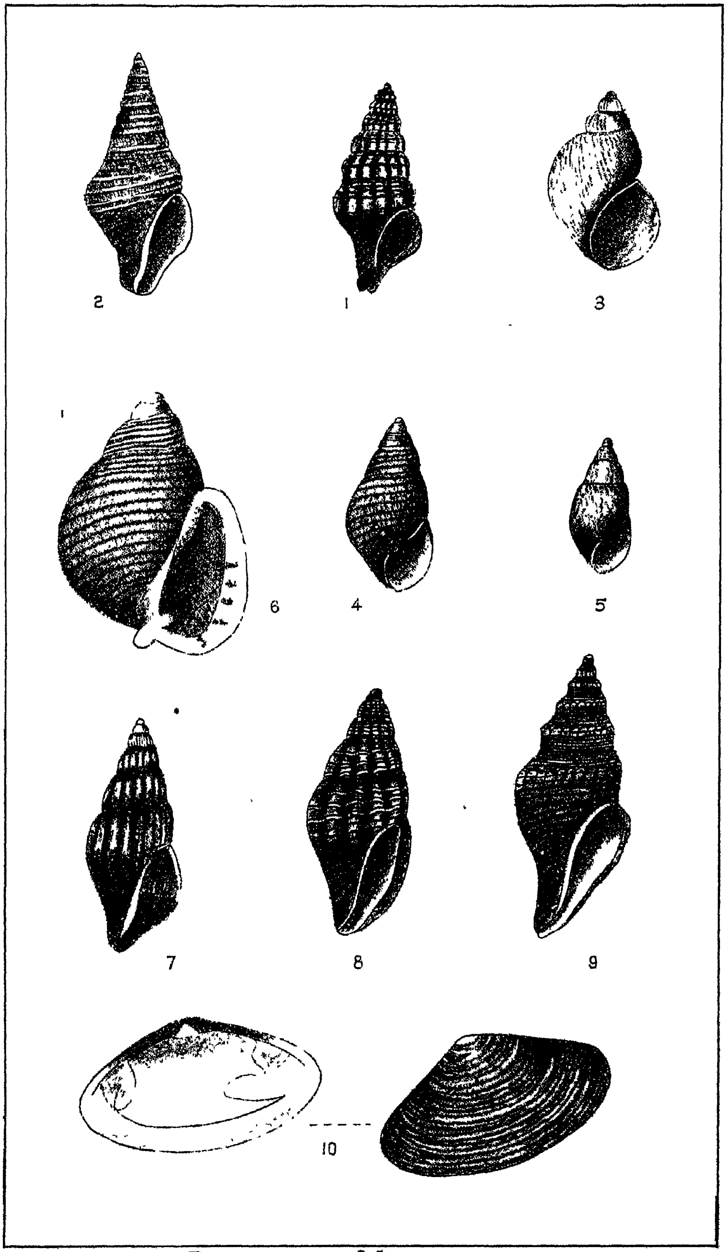
HAASTIA PULVINARIS.

(Low)

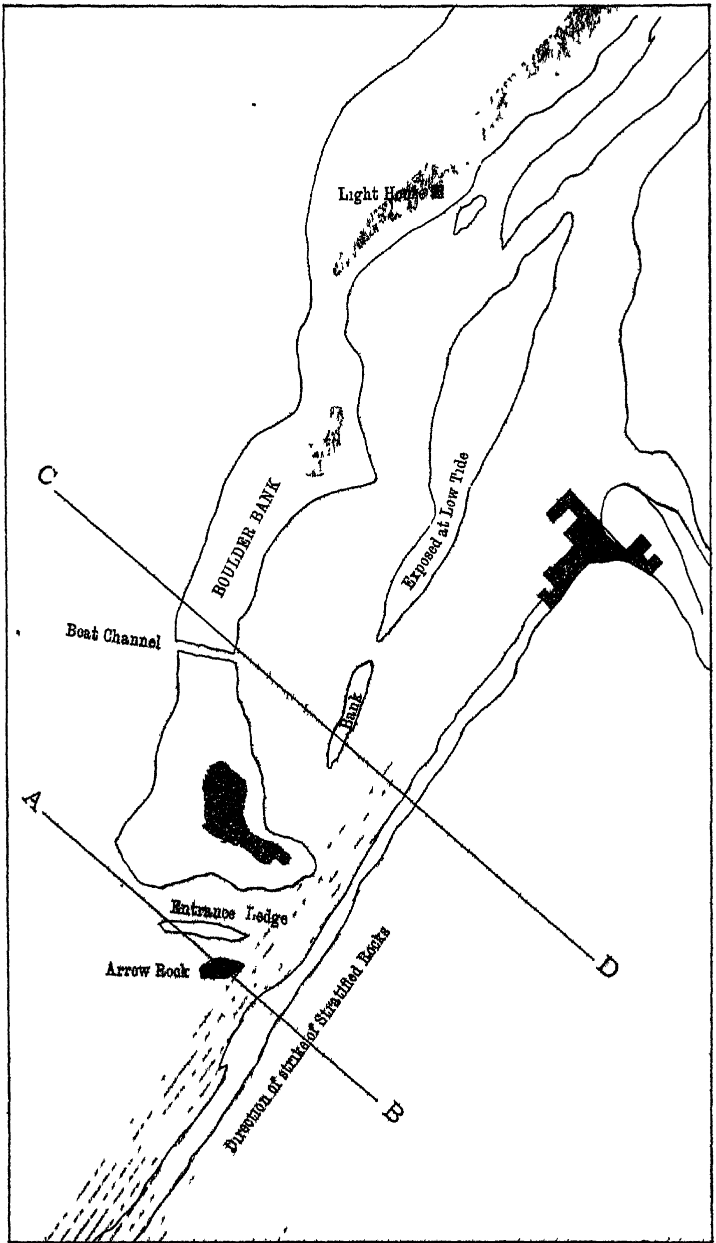


HAASTIA PULVINARIS.

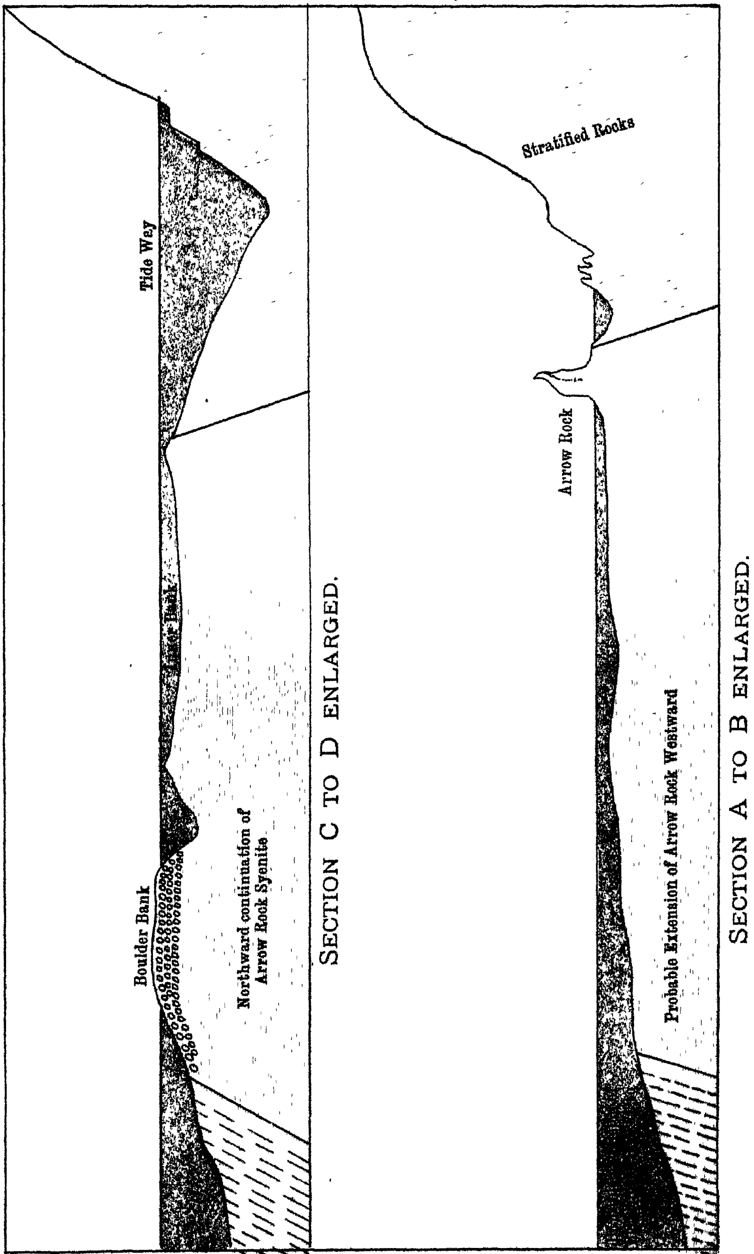
(Low)



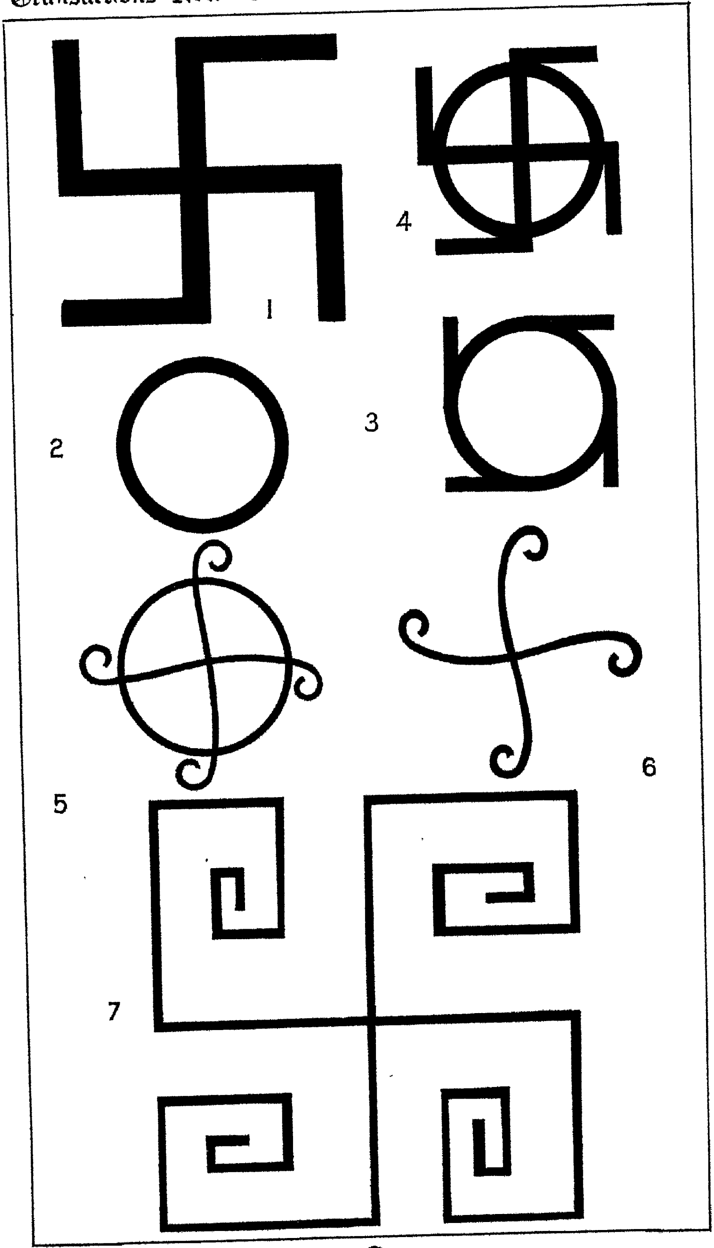
PLIOCENE MOLLUSCA.
(Murdoch)



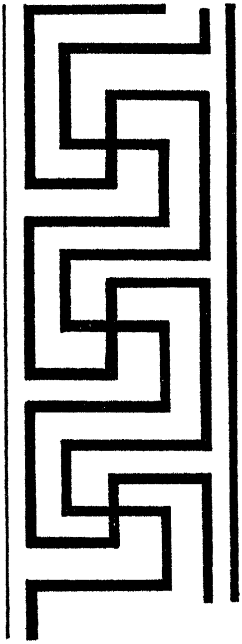
NELSON BOULDER BANK
(Worley)



NELSON BOULDER BANK
(Worley)



MAORI SPIRALS
(Tregear)



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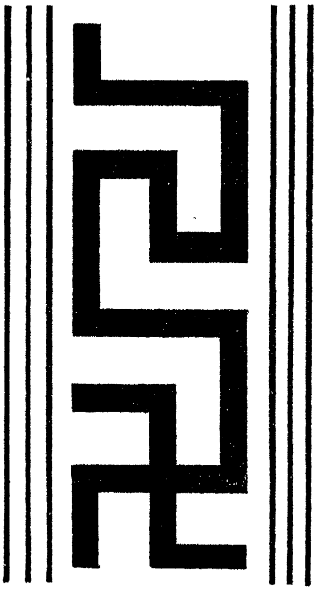

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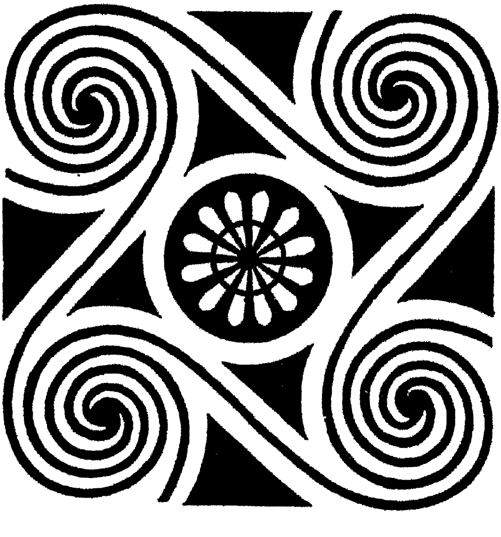

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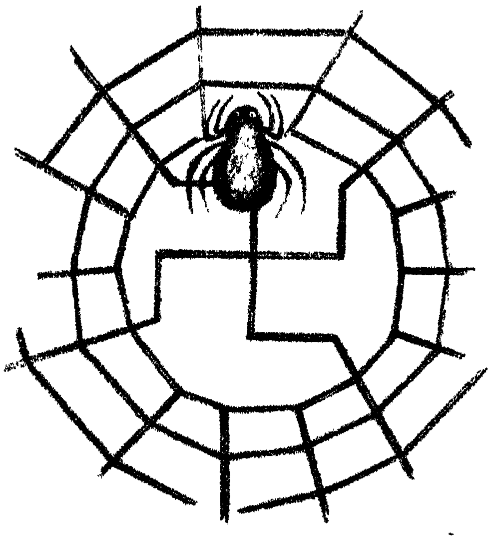
MAORI SPIRALS

(Tregear)

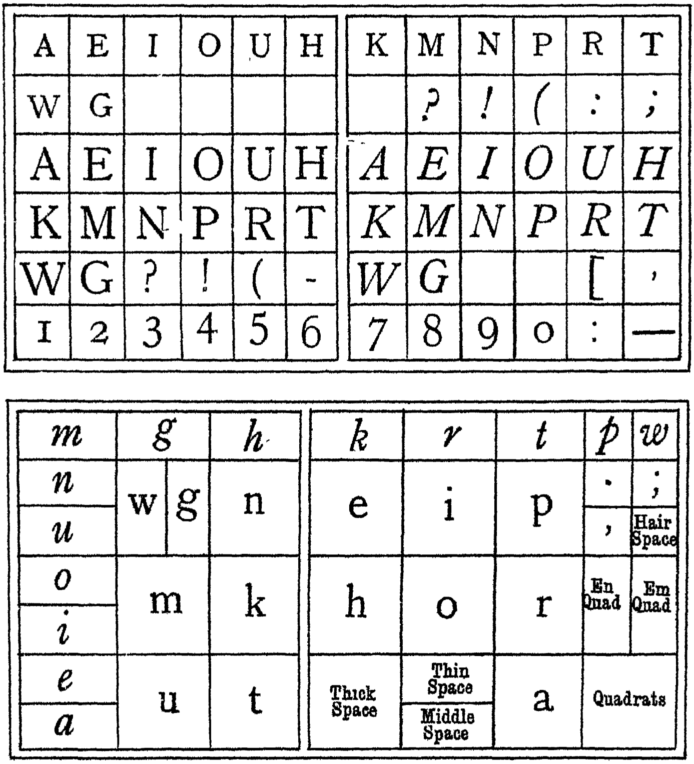
11

13



MAORI SPIRALS

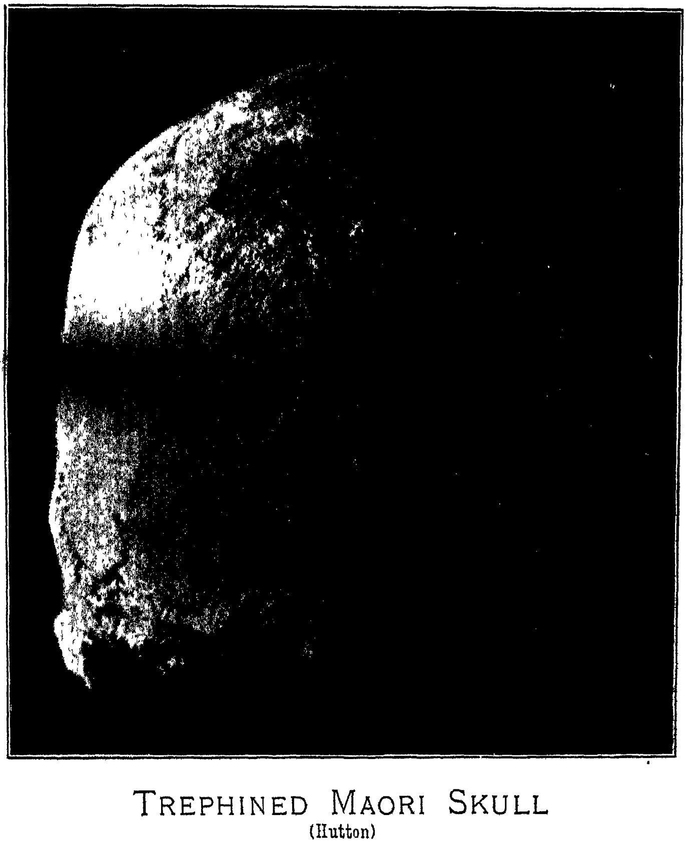
(Tregear)



Relics of the Old Mission Press

THE PAIR OF MAORI TYPE CASES

(Harding)



TREPHINED MAORI SKULL
(Hutton)

Date of issue.	Date of issue.	Date of issue.